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A Successful Gathering. THE meeting of the American Institute of Electrical Engineers at Boston, May 21, was a signal success in every way, and the members will long have occasion to remember with pleasure the warm hospitality that greeted them. The papers read were of great interest, and we take pleasure in presenting in full all that have been given out for publication by the secretary of the Institute. It is to be hoped that the great success of this experiment of temporary migration of the Institute will be followed at other times. It must lead to more intimate and friendly relations between electricians of various sections of the country, and will give the opportunity of attending meetings to members who find it hard to reach New York, which has heretofore being the ordinary place of assembly.

Self-Induction of a Circular Loop. SELF-INDUCTION is one of those things which is at once important and much neglected. The growing application of alternating currents has compelled advances in the theory of the subject, and though the mathematical path of progress is beset with pitfalls for the unwary, it is not impassable. In his note published this week Mr. Blâthy, well known through his connection with Ganz & Co., gives an ingenious solution for the self-induction of a circular loop. It appears in a comparatively simple form, and is an interesting addition to an important branch of electrical theory.

Kemmler to Die. AS WE ventured to predict at the time of its original introduction into the legal mysteries of the Kemmler case, the Supreme Court of the United States has refused to interfere with the action of the New York courts in regard to death by electricity. The main interest in the decision handed down on May 23, to electricians at least, is in the statement that the New York Legislature acted humanely and wisely in abolishing the torture of the gallows. There now seems to be little doubt that Kemmler will suffer the death penalty, and that the date set will be late in the summer. The question raised in another court as to who should act as executioner is of no vital importance, so that little remains to be done to effectuate the condemned man's legal death.

An Advance in Photometry. PROFESSOR NICHOLS' interesting note on a new photometer is a distinct addition to our means of solving that very exasperating problem, the determination of the candle-power of an arc light by reference to usual standards. Photometry, in cases where lights to be compared are of the same color, is exceedingly easy; but the comparison of a brilliant white arc light, far richer in blue rays than ordinary illuminants, with the candle or gas light used as a standard, is a matter of great experimental difficulty. The ingenious modification of the spectro-photometer described by Professor Nichols goes far to simplify comparisons, and the results obtained with it show a very satisfactory degree of accuracy.

Leakage Coefficient of a Motor. Mr. H. F. PARSHALL'S note on the magnetic properties of the Sprague street car motor is an interesting addition to the literature of magnetic leakage. In the ordinary forms of dynamo the values of this coefficient are tolerably well known, although the values met in practice are frequently larger than those found in careful experiments, owing to bad joints. Motors of the form used for railway work are specially worth studying, as they have all sorts of projections that make the leakage rather high. Mr. Parshall's results show that the magnetic qualities of the motor in question are decidedly good, rather better than was to be expected, considering the fact just noted. The difference between wrought and cast iron pole pieces proved to be particularly small. It would be interesting to repeat such a test after the motor had been in rough service for a year or so and had been taken apart and put together again several times.

How Not to Build Conduits. SOMEHOW there seems to be a sad lack of continuity in the mandates of the mayor and the resulting subways. His Honor seems to be of the opinion that the only thing necessary to put the wires underground is a blast on the official horn. But subways are not constructed of wind, neither can they be built at a moment's notice of any other material. There is something positively refreshing in his Honor's order for the invention of a method of leading working ducts to the main conduit without digging up the pavements. Apparently he supposes it is only needful to punch a hole in the ground, when the wires will at once crawl in, gnaw into the subways, and connect themselves with neat soldered and taped joints. If the electric lighting companies are compelled to suffer an additional burden of rates imposed to pay for these official vagaries, their condition will be pitiable. The spasmodic kind of virtue that suddenly insists on the pavement remaining intact through all time may comfort the public until the next job arrives, when its true inwardness will appear.

Arc Light Carbons. THE discussion of the life and efficiency of arc light carbons by Mr. Marks, published in full elsewhere, attracted no little attention at the meeting of the Institute. The work done was an admirable example of the application of scientific investigation to economical problems, and it is the more satisfactory as its results appear to be in thorough accord with such isolated facts as have been made evident in the course of commercial practice. It is surprising to most persons, who have not made a special study of the problem, to learn what differences in life and efficiency are observed in the arc light carbons in general use. It is also important to notice that not only do different carbons give widely different results in general, but each system requires a special grade of carbon for economical service. Carbons suited to high tension systems may fail completely on low tension systems carrying a heavier current. Not only did Mr. Marks investigate the questions of life and relative efficiency, but also the absolute efficiency of the arc as a transformer of electrical into luminous energy. The result obtained was in accordance with previous figures, and showed that of the energy delivered to the lamp from 9 to 12 per cent. only is returned as available light.

Electricity and Fires. THE workings of the human mind are often past finding out, but perhaps the most inscrutable of intellectual vagaries is that which attributes the origin of all mysterious fires to electricity. If the "devouring element" merrily preys upon a deserted barn, the wiseacres will declare that it was led there by an innocent live wire on the next block. They seem to think that if no one saw the fire start it must have been set by an invisible agent, and what such agent is there but electricity? They follow a pole line to the scene of the conflagration with all the zest of an Anglomaniac hunting an anise-seed bag; and once in at the death, they speculate on the deadly nature of the fluid that evidently must have jumped across the street to start the flames. They never once think that a cat may have run into the haymow with a kerosene lamp in her mouth, nor imagine that the nails grew white hot from spontaneous combustion. Their hypotheses are neither ingenious nor plausible—they lack versatility. It is always the same old story—live wires, dead wires, telegraph poles—anything to put the responsibility on electricity. An occasional fire is doubtless produced by electric wires, but the number that can be traced directly to such cause is small, and it is hardly fair to put down all fires of unknown origin to the discredit of the usually innocent current.

A Distinction and a Difference. SOME few weeks ago we published a report from Mr. Mordey stating that the great alternating central station at Deptford disturbed the telephones in Paris. The statement seemed a marvellous one, hardly credible in view of previous experience in this country; but as it was given on the authority of one so well versed in such matters as Mr. W. H. Preece, a request was sent to that gentleman to give the facts in the case for the benefit of the electrical fraternity here. He has kindly responded, and states that Mr. Mordey somewhat misunderstood the action that really took place. The cables from the Deptford Central Station, carrying at the present time alternating current at a potential of 3,700 volts, pass quite near the London telegraph system, more especially the circuit from London to Rome via Paris. The telegraph service was frequently greatly disturbed, currents of as much as 18 milleampères having been detected on the lines, and the London-Rome circuit was rendered almost useless. A telephone placed in this circuit at Paris gave ready evidence of the alternations at Deptford. The Paris telephone system, it will be seen, was not disturbed, although a telephone inserted in the line in question as a test instrument gave clear evidence of the interference. The amazing statement made by Mr. Mordey is therefore not borne out by the facts, although the trouble from the alternating current was and is very great.

Electric Roads for Long Distances. THE paper on electric traction, by Mr. O. T. Crosby, whose portrait we give in this issue, marks a distinct advance toward the end to which the advanced guard of electricians is now looking. Mr. Crosby takes up at length the question that has previously been only briefly sketched out, and shows in considerable detail the relative cost of electric and steam locomotives operating on long lines. The fact is made evident that with a motor of high commercial efficiency long distance traction can be carried on as economically as with steam locomotives, especially if the speed to be reached is very high. Electrically the problem of high speed electric traction is not at all a difficult one; less beset with annoying details than ordinary street car service. Mr. Crosby shows distinctly that our street car motors at present do not have a commercial efficiency high enough to compete with the locomotive in railroad service; but in stating the difficulty he also has stated the remedy. The street car motor wastes no small proportion of energy in the complicated gearings that are necessary at present to reduce the speeds available on small motors to the speed desirable on street railways. If, however, the motor be applied to railway service, the speed naturally required is high enough to admit of an economical motor being applied directly to the axle without the intervention of gearing. Such being the case, the commercial efficiency of the electric locomotive becomes comparable with that now obtained from steam locomotives, and hence it is possible to conduct ordinary railroad service economically by the aid of electricity. Looking at the question in a general way, the amount saved by employing large compound condensing engines to generate power, instead of simple or compound non-condensing engines of smaller size, is sufficient to offse the cost of distributing energy by conductors along the line.

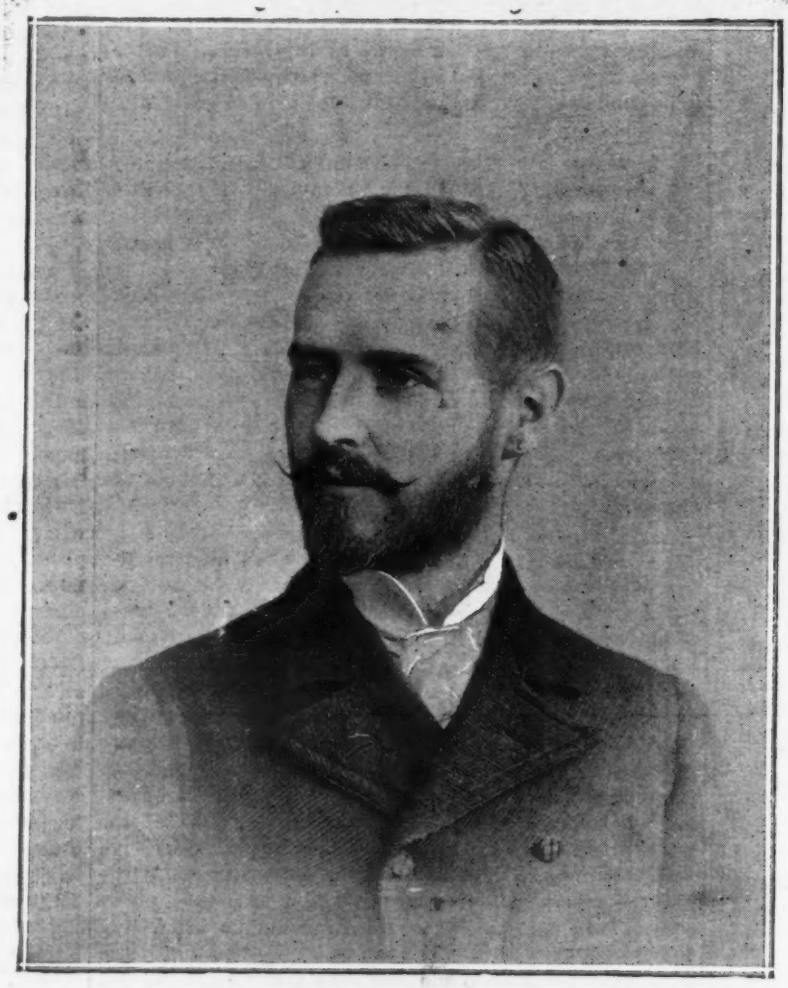
ELECTRICAL WORLD PORTRAITS.—XIV.

OSCAR T. CROSBY.

Mr. O. T. Crosby, well known to our readers as an expert in electrical traction, is one of the prominent group of electrical engineers who have taken up the profession after the careful education and training gained in the government service. He is a native of Louisiana, where he was born a little less than 30 years ago, and passed most of his boyhood in Brookhaven, Miss. From there he entered the U. S. Military Academy in 1878, and four years later graduated second in rank in a large class. On graduation he was commissioned as an officer in the engineer corps, and was stationed at Willetts Point, N. Y., where the torpedo system of the United States service has been developed. After two years spent in the study of this and other problems in military engineering, Lieutenant Crosby was sent to New Orleans for river and harbor duty. He remained at that station for two years engaged in planning and executing various works of improvement. In May, 1887, he obtained six months' leave of absence, and soon after resigned and joined the Sprague Railway and Motor Company in time to take an active part in the early development of electrical traction. He soon assumed the duties of superintendent of the company, and in that capacity was in charge of its manufacture and installation departments. He remained in the service of the Sprague Company for two years and a half, and in the course of his professional work executed various researches on the problems involved in electric railroading, some of which are already familiar to our readers. With the advantage of the splendid training acquired by these years of investigation and experience, he has undertaken the engineering of the Weems Electric Railway Company, and for the past year has been actively engaged in overcoming the difficulties that attend electrical traction at extreme speeds. His experiments have been remarkably successful, and in the course of them he has been led into scientific work of great and permanent value.

In connection with Lieut. Ruckman, Fifth U. S. Artillery, he has developed the Ruckman-Crosby Range and Position Finder, which has been ordered by the Board of Ordnance and Fortifications of our army.

His study on atmospheric resistance at very high speed, published in abstract last week, is a valuable addition to our knowledge, bridging, as it does, the gap between ordinary train velocities and the swifter flight of projectiles. We shall look forward to other important investigations from Mr. Crosby's hands, as his skill and experience must produce positive results in grappling with the pioneer work of extreme rapid transit. It is to men with the combined education and practical training of Mr. Crosby that we must look for the developments in electrical engineering that seem to crowd the future.



OSCAR T. CROSBY.

The Management of Accumulators—III.

BY J. K. PUMPELLY.

In speaking of the handling of storage batteries, it must be understood that all the forms of them now in the market are of the same chemical nature, and they are therefore all treated in the same way. Later on we shall describe the various mechanisms that mark the distinctions between them.

Let us pay close attention to the one we have supposedly made ourselves. According to the estimates mentioned in our last article, say there are thirty cells, of an efficiency of 100 ampères, and of an E. M. F. of 60 volts. These thirty cells are connected in series; that is, each negative pole is firmly fastened to the positive pole of the next, and each positive to the negative, until we come to the last of the thirty. Here, of course, we find a negative pole free at one end and a positive at the other. Now, to charge them, we connect the positive pole by a wire of sufficient size to carry the current we wish to charge with, without heating, to the positive pole of the dynamo, and in the same way the negative to the negative pole.

The dynamo for our use is shunt wound, and has been arranged to give a current of 15 ampères, which is continued for say seven hours, in which time we ought to have accumulated a capacity of $15 \times 7 = 105$ ampères. It may be that in our calculations we have wasted five ampères, not having surface enough to take them up. As to this we shall never know exactly, since if we get a successful discharge of 80 or 85 ampères, by an output of 10 ampères per hour, we shall be satisfied, and if the batteries are well made and work properly, such a discharge, at this economical rate per hour, can undoubtedly be obtained; more surely so, if part of the discharge is made in the day time, allowing the night to intervene as rest, for under such conditions, the night's rest seems to add efficiency to the battery, or rather, to regain some of the working ability already taken out.

The reader or experimenter can now understand how many exceptions there are to any rules laid down for handling these erratic things; many pages of a book could be filled with whys and wherefores on the propriety of doing this or that; and he can see how confusing and discouraging it is to the man new in the business to try to follow out such rules, even after he has made his battery, and is delighted and satisfied that it does anywhere near the work that it ought to do.

The writer, having been through this, is not quoting the dicta of others, who were, but a short time ago, the only authorities on storage batteries, and each of whom expressed his own theory; but is leading the experimenter and beginner by the hand, and with him is leaning over the mysterious boxes, watching every bubble that comes to the surface, disregarding the rising fumes of sulphurous acids, or the burning touch of the fingers to the electrolyte, in the anxiety to know if every contact is perfect, and that all is mechanically right.

It is not by books that we learn to manipuiate, but we do discover, by them, what the experience of others teaches, and know in this way what return we ought to have for our labor, and what, by the theories of advanced scientific students, we have a right to expect.

Since Salomons, Gladstone, Tribe and certain German scientists wrote on storage batteries, much has been discovered, and many improvements made; but after all, the mechanical combination of the lead support, with the more easily disintegrated oxides of lead, is of the first importance, and this can only be learned by experience, thought and ingenuity. There are many ways of doing the same thing, and as long as the plates of the positive and negative poles are held apart at the right distance, and all the negative plates are thoroughly connected, so that no action of the acid in the electrolyte will force them apart by corrosion, and the same is true with the positive plates, the battery will receive the charge as it should, and successfully do a certain amount of work in the discharge; but the difficulty is to make a battery in such a way that not only is this work done, but done economically and continually for months and years.

The writer, seeing in advance how important commercially storage batteries would become, has always striven to obtain durability, the lack of which has ever been a great objection to their use, and to do this he has departed from the usual form of mechanism obtaining in other batteries. But, to go back to one of the thirty cells that we have made together, it seems to be working well; the bubbles of hydrogen gas come slowly to the surface along the negative pole, the negative plate becomes gradually darker, and the positive of a constantly increasing maroon color; and after a constant charge of thirty hours, we find this color quite dark, and the surface of the liquid filled with sparkling dancing bubbles of gas, evidently of both hydrogen and oxygen. Then a slight milky appearance takes place and an acidometer placed in the liquid shows an increased specific gravity, making, instead of 1,150, at which we started, the record of 1,200, or even 1,210. We now conclude with safety that the battery is charged to the extent of its capacity. We disconnect it from the dynamo, before stopping it, by the aid of a quick-acting switch, through which the wires from the batteries should pass, which arrangement, by the way, we had forgotten to mention in explaining our first process of connecting. The reason for it is, that if we stop the dynamo, leaving the batteries still attached, the electromotive force that has been created in the batteries will react upon the dynamo, making a motor of it, or if the machine does not revolve as a motor, then the resistance will generate so much heat that the armature may be burned.

We are now ready to try our battery on some incandescent lamps. We have thirty cells, so we must use sixty-volt lamps, because each cell acts with a pressure or E. M. F. of two volts, and collectively with sixty volts. The current needed for each lamp is one ampère, hence we might expect to make one lamp like this burn one hundred hours, and ten lamps ten hours; but we find, after trying this in our first discharge, that but little over half of this expected efficiency is the result, and with it, terrible disappointment. Every point of contact is carefully examined, almost with a microscope, searching for the cause, but mechanically all is correct. The negative plates have lost some of their slate color, and show more of a gray tint, as they ought according to chemical theory, and the positive plates have changed from a dark maroon to a light claret color, which is as it should be.

Now, what is the matter? Let us think over this phase of the question, and as we are supposed to have no authority, not having read any books on the result of a first forming charge, we must rest on the theory declared by electro chemists, as to the composition of the plates after the first charge, and what is necessary to complete the charge in the lead oxides, in order to give a full efficiency in discharge. Thus reasoning, we may readily conclude this point without further aid or experimenting. A first charge, which we call the forming charge, does not fully, or even in any fair proportion, convert the litharge into a sufficient quantity of finely divided lead, nor the material on the positive plate, which was red lead, into a sufficient quantity of peroxide of lead, to produce the full percentage of chemical change necessary to do the expected amount of work.

On the strength of this reasoning we may expect better results on our second charge and discharge. Having therefore discovered, by our second, from the showing every hour on our ampére meter, that with 30 hours of charging at the rate of 15 ampéres, we have realized from the discharge only 50 ampéres, we begin again, and while the same current is running through our batteries, we will explain why we talk about 30 hours' charge, when, at the rate of 15 ampéres, seven hours ought to be sufficient to store up 100 ampéres for work.

It was found by Plancé that it needed a much larger charge of electricity to convert oxides of lead into such a condition chemically, than it does merely to charge fully formed batteries.

Frund's New Moonlight Table.

Mr. A. W. Frund has devised, and the Common Council of Vincennes, Ind., has adopted, a schedule of street light hours that seems a happy and ingenious compromise between the ordinary moonlight service and the over-expensive "all night and every night" lighting.

The ordinance of the council gives the scheme in these words:

Section 6. Said lights are to burn every night in the year from dusk to midnight, and after midnight every night in the year according to the American Meter Company's schedule and calculations of public lighting, except the three nights immediately preceding the full moon in each month and except in case of an unavoidable cause or accident; for which said city is to pay to said company the sum of $80 per annum for each light.

The features noticeable here are, first, that the lights always burn until midnight; second, that after midnight the moon schedule is followed; and third, that during the three nights immediately preceding full moon the lights are not turned on after midnight. Mr. Frund proposed the latter modification of the usual lighting table for the good reason that on these three nights the old tables give but an hour or less of lighting, and even that is well on toward sunrise. It is obviously a great expense to light the lamps for these few minutes, and the light is in reality hardly needed, for the difference between moonset and sunrise is then such that an abundant twilight is afforded. Thus it will be seen, by taking the calendar for any such day, just previous to the full moon, that the need for lights after midnight is practically *nil;* especially when it is remembered that the ordinary moonlight tables requre the lamps to be lighted one hour before moonset. It sometimes might even happen that the lights would be burning, with the moon still above the horizon and the sun already there. This waste is what Mr. Frund avoids.

All night lighting gives from 3,800 to 4,000 hours per annum, while the moonlight schedule gives about 2,200. Mr. Frund's plan seems to us to be almost as good as the all-night system, and it calls for but 3,000 hours. The Vincennes Electric Light and Power Company, of which he is superintendent, deserves to be congratulated, and so does the city of Vincennes. The contract between the two runs for ten years, and is in other respects an admirable document.

A New Conduit System.

The "P. & B." Conduit and Construction Company's conduit system, of which we present several illustrations this week, is an important addition to the number of proposed solutions of the underground wire problem. Its main feature is the use of wood prepared by the P. & B. processes, securing economy, strength, insulation and durability; but in several details the system embraces modifications and improvements upon existing conduits.

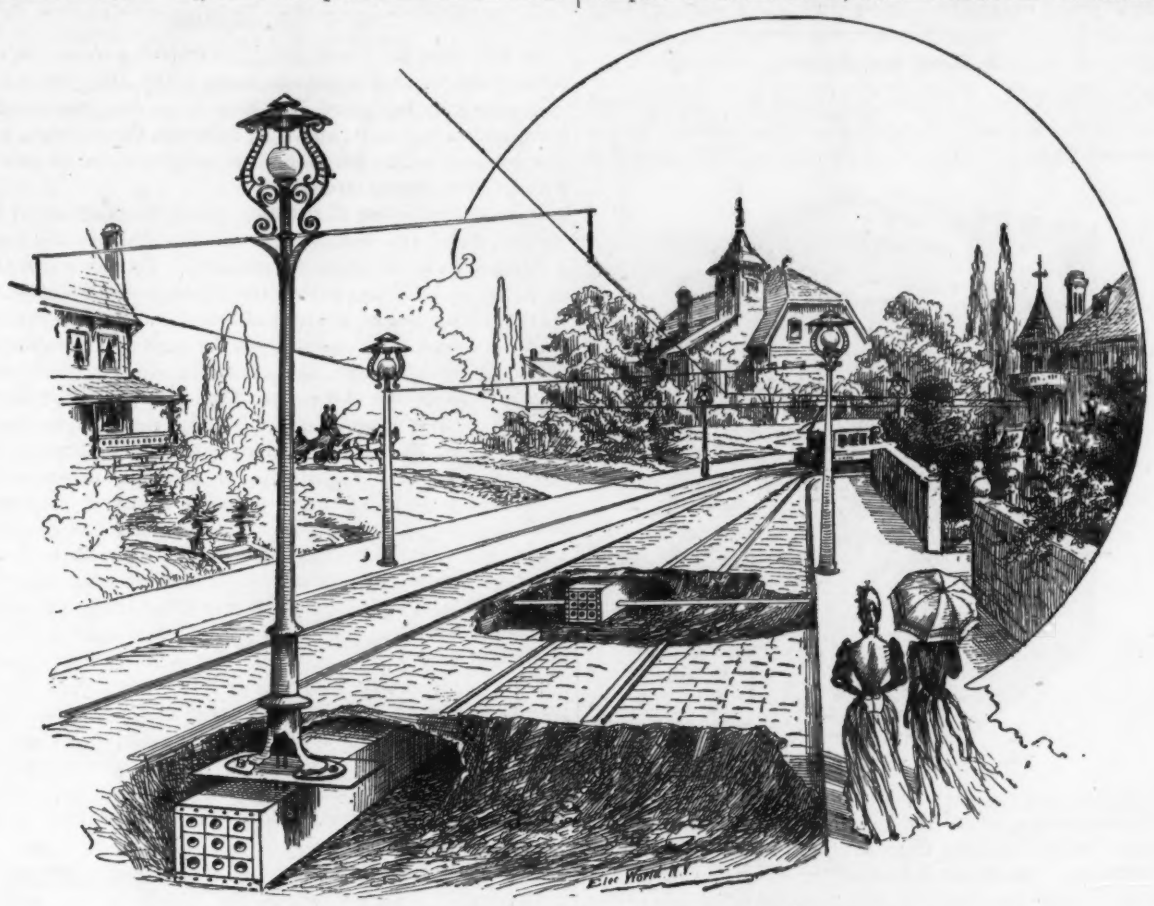


FIG. 1.—P. & B. CONDUIT—PLAN FOR STREET SERVICE.

It is now believed by many that underground conduits should be so constructed as to permit cables to be drawn in and out, so as to provide for extension of service and the replacement of wires injured or found defective. With small or composition-filled ducts a defect in the wires at any point may involve very expensive and laborious upheaval of streets, as well as the prejudice against conduits that such upheavals inevitably produce.

An ideal conduit should be proof against injury or disturbance from neighboring excavations made for gas and water pipes, sewers or other purposes; it should prevent the infiltration of water percolating through the earth, this being, in all older cities, charged with ammoniacal and other salts; it should prevent the penetration of gases; it should be constructed of materials not in themselves harmful to insulation nor capable of creating electrolytic action; and, finally, it should be built so as to render easy the drawing in and out of cables and the furnishing of local service. If such a conduit can furthermore be both cheap and durable, little more could be desired.

The wood prepared by the P. & B. processes is claimed to make possible many of these *desiderata*. That wood may be serviceable in underground work is shown by the pipes 80 years old that have recently been dug up in the streets of New York, and that may now be seen in several shop windows on Nassau street, as sound as the day they were laid. The wood for the P. & B. conduit is first thoroughly kiln dried by hot air, thereby solidifying the albuminous particles and driving out all moisture. While hot it is submerged for some hours in tanks filled with P. & B. compound, which is already largely used as an insulator for electrical conductors and appliances. It is said that it is acid and alkali proof, and that when applied to wood or other porous material it fills and seals the same, rendering it absolutely impervious to the passage of water or gas. The company have evidence showing that wood so prepared is practically indestructible by decay.

That the conduit proposed is commercially advantageous is evident from the cost of the material used and from the compactness of the mains, well shown in our illustrations, making the expense of trenching, repaving, etc., comparatively small. The manholes (Fig. 3) are both water and gas-proof, and are, in the opinion of the company, more durable and better adapted to their work than those built of brick and cement. The junction box, shown in Fig. 2, is made of cast iron and has a wooden block coated with P. B. compound fitted inside. Upon the wooden blocks are affixed the metal plates with binding posts and fuse clamps, and as may be seen, each with a wing extension having cut-out plugs and smaller fuse clamps for service wires. On either side of these two central fuse clamps is an independent plate with clamp and cut-out plug; but both are connected by a wire or other metal connection soldered to the bottom of the plate and running in a groove in the wooden block; and also soldered to the main plate on the opposite side or to the wire carrying opposite polarity. The wire carrying the positive current is connected to one pair of plates and the negative to the other.

Thus a + and a — pole are side by side in the box shown, two on each side; and four services may be taken from the main feeder, each independent of the other, and so arranged that any one service may be cut out without interference with any of the others, and without necessitating cutting off the wire; manifestly a *desideratum* in case a fuse should burn out or a service need cutting out for any reason.

The main wires are held in clamps, so constructed that they cannot work loose or fail to keep a good contact. There is a spring tension on the upper half, and should there be any give to the copper wire the spring of the cap follows it up. The main feeders and service wires are led into and out of the box through joints which, after the wires are placed in position, are hermetically sealed with asphaltum or some insulsulating water and gas-proof compound. The cover being fitted with gaskets, the box is made water and gas-tight, so that there is no danger of short circuits by reason of defective joints and water accidentally filling the manhole, nor of explosions from accumulation of gas. Should it become necessary to change a main feeder, no joints need be disturbed except its own, leaving services intact. This seems to be a new and important feature. By the use of this system of conduit and junction box the changing of cables is rendered convenient, economical and speedy, requiring no disturbing of streets to cut off services and re-connect same.

The conduit may be of any desirable size. That shown in Figs. 1 and 3 consists of nine main tubes, each in a separate square wooden stringer. As these beams are in various lengths, and as no two of them ever break at the same point, the trunk when completed is practically a solid wooden duct of any required length. The smaller holes, above, below, or at the side of the mains, are for leading service wires from junction boxes to points where needed.

The plan of making all connections to main feeder in junction boxes and manholes, running service wires in the smaller ducts, seems at once the most economical and practical electrically.

The use of round wood tubes for the laterals carrying wires from the service ducts to buildings and posts is also favored.

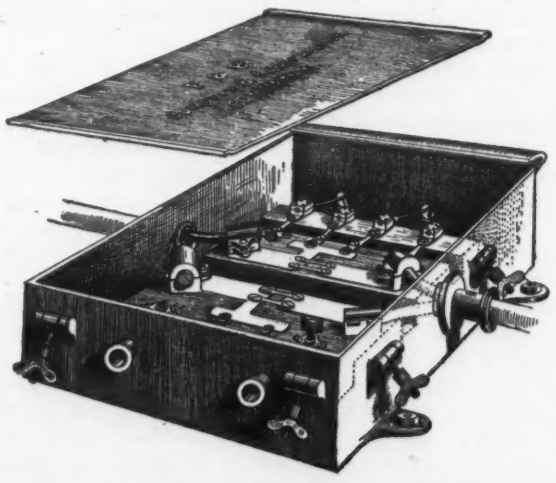


FIG. 2.—P. & B. CONDUIT JUNCTION BOX.

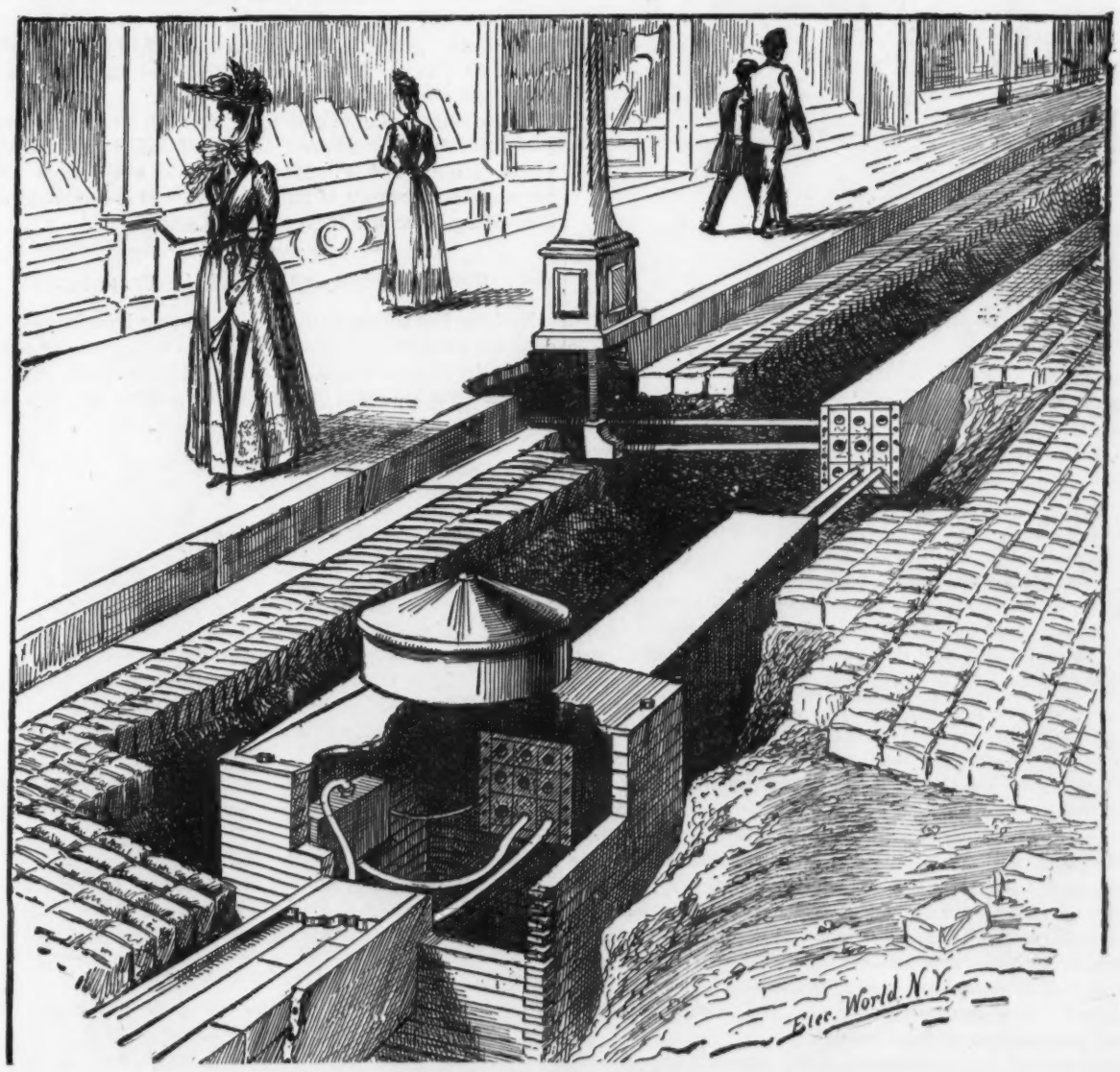


FIG. 3.—P. & B. CONDUIT SYSTEM; MANHOLE.

The P. & B. Company present many reasons for claiming the superiority of their conduit system. Among them are the following:

1. It is constructed of a material which can in no way injuriously affect the insulation of wires.

2. The compound is a non-conductor of heat and will preserve the insulation from climatic changes as well as from the heat of underground steam pipes, if in close proximity.

3. The ducts being of wood, and so placed together that joints do not coincide, the conduit or several ducts becomes self supporting and the disturbance of the earth will not affect the alignment of any of the ducts.

4. The conduit being built of independent ducts any accidental injury to one does not affect the others, as in cement, concrete or asphalt.

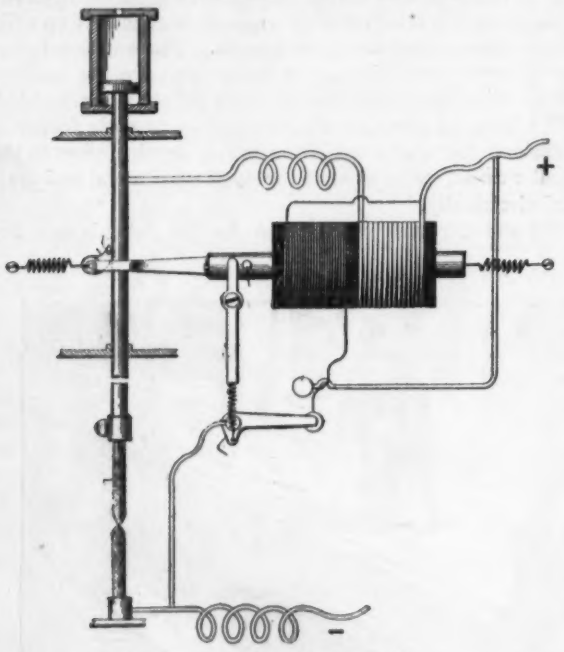
5. The core of main feeder ducts having plank cover and bottom, and side service planks, all fastened together, it is not only strong but absolutely tight as well.

6. As an argument that the P. & B. compound of itself is valuable for underground electrical purposes, the company cite the fact that lead-covered cables have been coated for the last three years with it, to protect them from destruction by wood acid, creosote, sewer gas, electrolytic action, etc.

The Breese Arc Lamp.

Mr. Charles P. Breese, of New York City, has just obtained a patent for his improved feed mechanism and cut out for a single lamp, as shown in the accompanying cut.

A solenoid magnet, horizontally arranged, has coarse and fine wire coils wound in opposite directions, the former being in series with the arc and the latter a shunt thereto. The extended end of the core has a jaw in which an upwardly curved cam is pivoted, so that its face may rest against the upper carbon rod and lift it for striking the arc when the current enters the lamp and the magnet is energized. Counterbalancing springs attached to the ends of the core serve also to support the core freely in the solenoid. When consumption renders the arc too long, the respective diminution and increase of current in the coarse and fine coils cause the core to move out so that the cam allows the carbon rod to descend by gravity until the proper length of arc is obtained, when the restoration of the proper relative strength of current in the two coils causes the cam to engage again and hold the carbon; movement of the carbon rod is cushioned by a dash-pot.



The Breeze Arc Lamp.

When the arc becomes too long and the rod fails to feed, or when from any other cause the current in the fine or shunt coil becomes abnormally great, the core moves out so far that a small pin carried by it engages the upper end of a lever which has one end of a spring connected to its lower end, and carries the spring past the pivotal centre of a switch, to an extension or arm of which the other end of the spring is attached. This switch, as is shown in the illustration, cuts out the current from the lamp and magnet.

Artificial Gutta Percha.

The English papers state that the artificial gutta percha, of which they have been talking for some time, has been examined by Mr. Latimer Clark, F.R.S., who has expressed his approval of its general qualities, being entirely distinct from those of the "rubber substitute" he has had hitherto brought to his notice; but he has not yet tested it electrically. Full tests are promised as soon as possible by those in whom the public can have confidence. A great many requests for samples have been received, which it has been impossible at present to supply, and orders have also been received. The stuff burns only with great difficulty, which is an advantage over most insulators.

Five kinds have been made. Three are soft and elastic, like cured rubber; two other kinds are hard and elastic, resembling hard wood or bone, except in elasticity. A sixth is nearly finished, which will be lighter than water, but is not intended for electrical purposes. The specific gravity of those now made is from 1.5 to 2.75; the specific inductive capacity averages 2. The insulation resistance is given as higher than gutta percha—about equal to glass. As to cost, by purchasing the raw materials by the ounce and working them up in the laboratory, the cost has been from 2½ to 4 cents per pound. Therefore, on the large scale it should easily be made for 2 cents a pound. The colors hitherto made are black, dark blue and three shades of brown. The inventor of the material is Dr. Purcell Taylor, who has named it "Purcellite." The difficulty with regard to the supply of gutta percha is an increasing one, and it is very evident that such a material as this is stated to be, if it prove applicable practically and the resistance insulation keeps its value, would prove enormously useful in electrical industries.

A Novel Dry Battery.

The accompanying illustrations show the exterior and detail of the dry batteries lately put in the market by the Nowotny Electric Company, of Cincinnati. This battery is

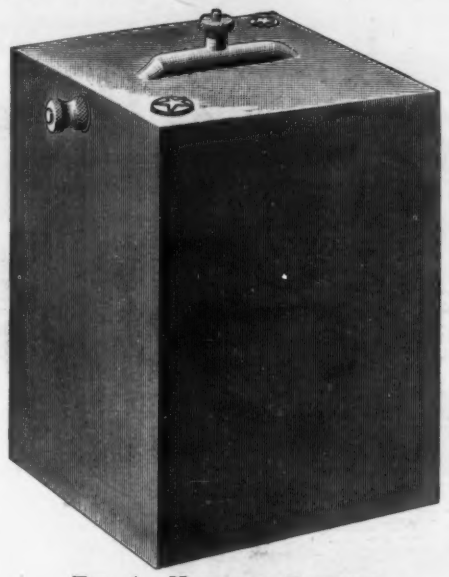


Fig. 1.—Nowotny Battery.

peculiar in that the outer cell is made entirely of carbon, and has a carbon diaphragm dividing the elements into two compartments, making it equivalent to two cells, coupled in quantity. The result is that a large carbon surface is exposed, while the voltage and internal resistance of but one cell are given, and that with the quantity of two cells.

As shown in Fig. 2, the zincs are cast in one piece and united at the top binding-post. The terminals are electroplated with iridium, protecting the contracts against corrosion. The battery is put up in dry form, hermetically sealed, and ready for use, as shown in Fig. 1.

The Nowotny company claim that the battery can be recharged when exhausted, and this can be repeated a number of times, giving a life of from one to five years; at the end of which time the cell can be returned to the maker and a new one obtained for half a dollar.

A dry battery should give high voltage, great quantity, and low internal resistance, and this is said to meet these needs with an E. M. F. of two volts, and with three ampères and a resistance of but 1.6 ohms. It is certainly an interesting departure from the usual forms.

The Grotesque and Absurd in Prophecy.

Nothing less strong than this caption, we imagine, would describe the feelings expressed by the average reader of an article in *Harper's Magazine* for January, 1856. If the general historian finds it difficult to "assume the contemporaneous viewpoint" in dealing with the past, how much more difficult is the task of the electrician!

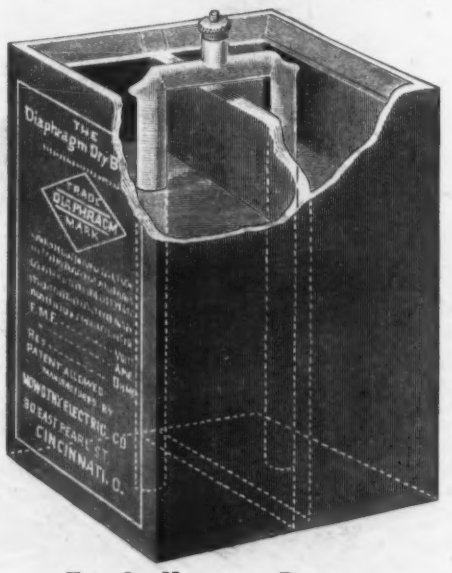


Fig. 2.—Nowotny Battery.

Here is a dreamer, a fanatic, a fabulist, who, in one of his wildest moments, ventured to predict that in the year 3000 men would be able to attach an ear-tube to a wire and hear conversations two miles away. He even went further, and declared that in the course of a dozen centuries news would be printed by electrical means on rolls of paper, and distributed directly to the public; and, not satisfied with this, he predicted that fac simile reproductions would be transmitted by wire, while he also foresaw the substitution, referred to by us recently as an accomplished fact, of electricity for the existing tip-demanding waiter.

It is not easy to realize that, since the *Harper's* ingenious contributor thus gave rein to his imagination, there have elapsed not the twelve centuries he expected, but merely a matter of less than two score years. Does the world understand the speed at which it is advancing?

A Remarkable Flash of Lightning.*

BY W. KOHLRAUSCH.

On May 15th last I was asked to inspect a stable on the farm of Mr. C. Jagau, near Hanover. On May 8th it had been struck by lightning, which set it on fire and killed a horse which was in it, and this, although the building had four conductors, in the immediate neighborhood of one of which the lightning struck.

The accompanying illustration shows the positions of the buildings and the conductors. To the east lies the yard, which seems to be quite unoccupied. To the south also there are no buildings within the distance of 100 metres. It was at the request of Mr. Rudolf Siemsen, who had erected the conductors, and I went to see the place. The iron rods are 4 metres high and the 12-strand copper conductors have a cross section of 0.06 in. The earth-plates are 100 by 50 centimetres; those at *a* and *b* hang right under water in two wells; that at *c* is buried 1.5 metres deep in the ground. From the gilded tips of the rods down to the earth-plates all joints were properly soldered. It might have been well to connect rods 2 and 3 along the roof, but with that exception no fault could be found with the arrangements. Those in the house had no idea that the stable had been struck until, shortly after, they saw smoke coming from the roof, and found that some loose hay lying in the loft was burning, which was easily extinguished; but it was found that a horse was lying dead just within the door. Distinct traces of the flash, in the form of numerous small splinterings, could be seen on the first two beams going to the northwest, under the ceiling of the stable behind the door *e*. Wood was splintered both on the inner and outer sides of the

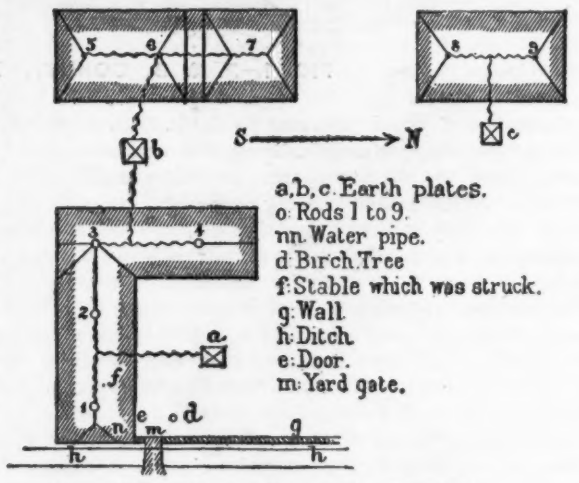


Diagram of Buildings Struck.

door itself, and here and there its nails and bars were melted at the ends and angles. The yard gate was also splintered. Finally, on the birch tree *d*, at about 1.7 metres from the ground, we found two burns, which were undoubtedly fresh, and which had gone through the bark to the better conducting interior of the tree. The most careful search has not brought to light any other traces of the lightning's course. We took down the conductor 1, but even with a magnifying glass could find no traces of its being touched by lightning. Rod 2 we examined through a telescope with the same result. The common conductor of rods 1 and 2 goes to earth at the well *a*. The water was about 1.5 metres below the ground. The well is built in sandstone, and is about 3.5 metres deep. The earth-plate *a* was quite under water.

Earths *a*, *b*, *c* were 10 ohms, 11 ohms, and 32 ohms, respectively. There is thus nothing much to be said against the arrangement of the conductors. It would have been better had the resistances of the earths been smaller, and had rods 2 and 3 been connected; but I think one can hardly say that the buildings were insufficiently protected, and I can find no definite reason for the fact that the lightning injured them; and, moreover, injured them at a spot certainly not beyond the commonly supposed protective distance of the rod, and which was nowhere more than five metres from either end of the rod. In this region the ironstone, which lies generally about a metre below the surface, in various sized beds, has a great deal to do with determining the course of a flash of lightning; but, on digging in the stable, near the birch, and round the neighborhood where the lightning struck, we came to the water-level at 1.25 metres down, but found no ironstone. The nearest we found was a small bed in the field, toward the east and about 25 metres from the stable. The field lies about 0.8 metres, and the water in the ditch *h* about 1.3 metres lower than the yard. In the stable or beneath it was no amount of metal worth mentioning. No farm implements were kept there; the stable was empty, save for the horse, which happened to have been put there temporarily.

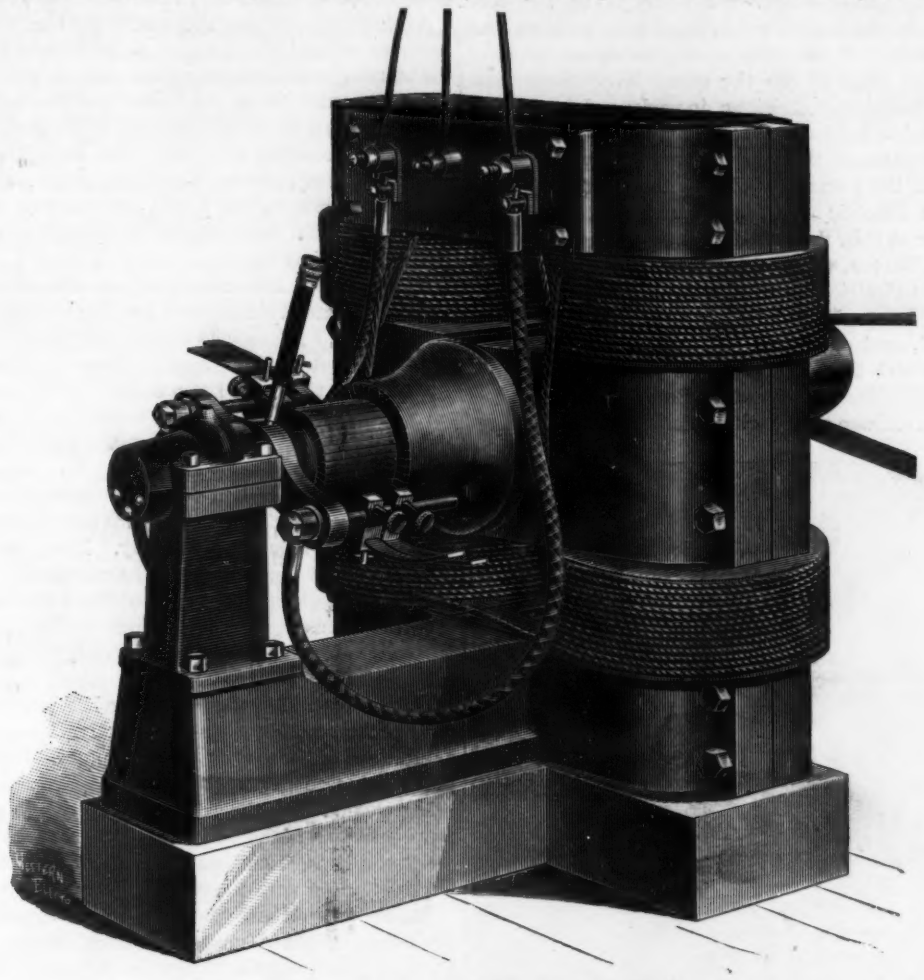
The following explanation is possible: The lightning struck the highest point in the neighborhood, the birch *d*,

*From the *Elektrotechnische Zeitschrift*.

passed through the twigs at *n*, which touched the roof of the building, and also through the tree, coming out lower down the tree, from whence it injured the yard gate *m*. All visible traces left by the flash fit in with this theory, for all the injuries to the building itself are just under the twigs *n*.

Foree Bain's New Motor.

The accompanying cut shows a 7-h. p. electric motor of a pattern that has recently been designed by Forée Bain,



FOREE BAIN'S MOTOR AND DYNAMO.

of Chicago. This motor is now in use operating a large freight elevator and paper cutting machine; and not only does its work well, but obtains, on testing, a high efficiency. The field magnets consist of two shafts of Norway annealed iron, clamped at either end by the double-yoke pieces, and midway by the pole pieces. The field, it will be observed, is of the consequent pole type, but with the field magnet coils vertical instead of horizontal, as is most frequently the case in machines of that design. The arrangement of pole pieces thus gives a well balanced field, while the shortness of the magnetic circuit insures efficient maintenance of magnetization. The coils are wound on spools and slipped over the magnet cores. In this particular motor the spools are only three inches long. The armature on an inductile velocity of 48 feet per second gives 1.4 volts per foot of active wire, the current density in the armature being at the rate 2,700 ampères per square inch. The field is maintained with less than half an ampère and has 1,300 times the resistance of the armature. The motor runs quietly and gives very nearly constant speed with variable load. This construction of Mr. Bain's is equally well fitted for use as either motor or dynamo, and when used in the latter way gives excellent results. The sizes in which this type is built are intended to be from 5 to 100 h. p , the largest sizes being compounded. The general design of the machine commends itself, as will be seen from the cut.

Shades of Horace!

The London *Electrical Plant*, whose editors are evidently classicists as well as electricians, is somewhat disturbed by the announcement that an electric road is to traverse the length of the Via Flamina, near Rome. It says:

"One can almost take refuge in anachronisms, and imagine Hannibal in a top hat, black suit and silver-tipped-well-wrapped-up umbrella, frantically hailing one of the cars, on the knifeboard of which are seated Nero and Mark Antony smoking cigars, whilst Cornelia with her boys and a dozen brown paper parcels of groceries, pulls out her purse to give conductor Cincinnatus five denarii."

But on the whole our British contemporary finds more to regret in the absence of electric tramways in England than in their presence on classic highways, for it continues :

"There's a pleasure in joking about such things abroad, but when we realize that no one seems ready or willing to give us a chance of commenting upon electric tramways at home, a laugh comes on the other side of the face, When are you going to stir yourselves, you tramway companies and electrical engineers?"

Would it not be well for the English editors to take a run "over to the States," as they say, and see what we are doing in the way of electrical traction?

Electricity Supplants Steam.

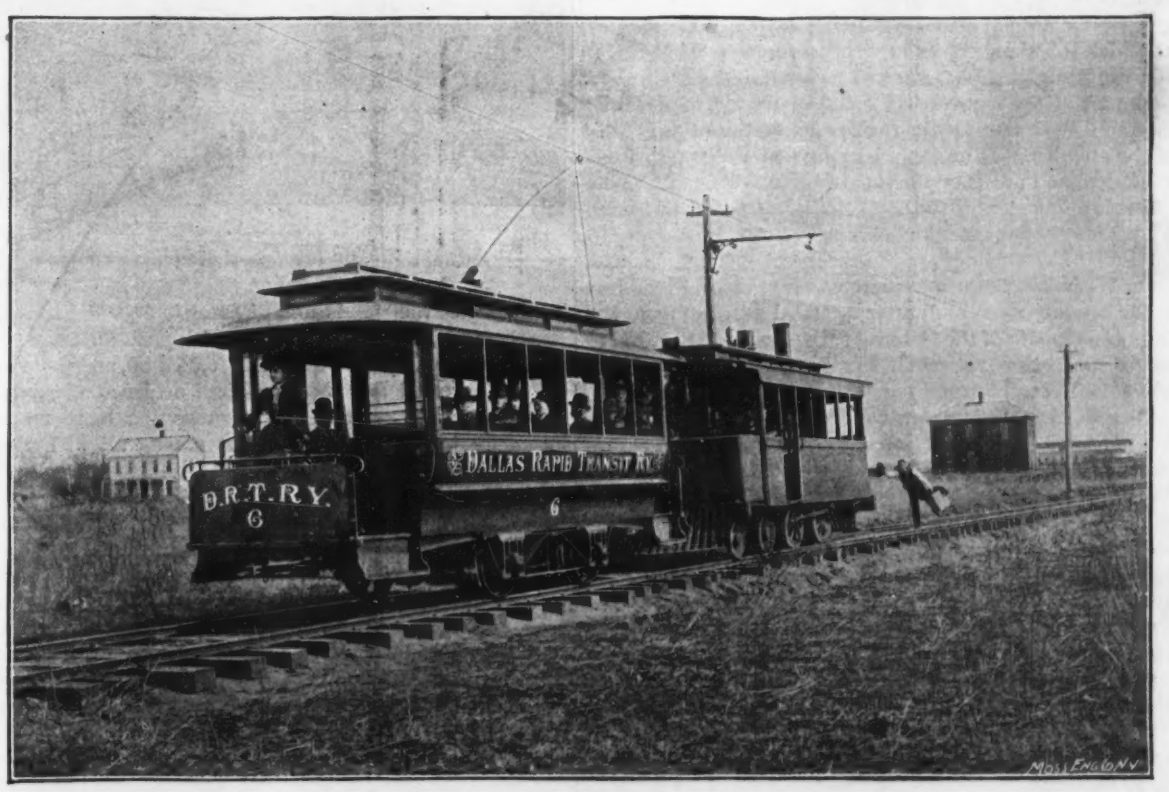
The subject of electric railroading has received a great deal of attention in the Southwest, and that part of the country is fully awake to the advantages of electric power for car propulsion. The State of Texas now has two electric railways in operation on the Sprague electric system, and others are in course of construction. One of the roads in operation is the Dallas Rapid Transit Railway, a view of which is shown in this paper. The motive power for operating the cars on this railway was formerly furnished by a steam dummy, which has now been abandoned for the more modern system.

Our view shows one of the electric cars drawing the old steam dummy. The engraving was made from an instantaneous photograph, and shows the ex-engineer of the steam engine trying in vain to catch the train which is going so rapidly that he is left behind.

An interesting circumstance in connection with this view, which shows very clearly the easy manipulation of the electric car, is the fact that the motor car is being operated by a young lady who is in charge of the controlling switch, while another young lady is acting as conductor. By way of comparison it might be mentioned that the steam dummy required an engineer and fireman to run it, besides a train conductor on the train.

The electric road has proved very popular in Dallas, and has carried a large number of passengers since its installation.

The method of overhead construction used is the single bracket, as shown in the illustration.



SPRAGUE ELECTRIC RALWAY, DALLAS, TEX.

Another New Dry Cell.

Edward Bender, of Brussels, has taken out German patents for a dry battery in which novel means are employed for preventing the drying up of the exciting liquid, and also for preventing polarizing. He makes the exciting mass of ammonium chloride and chalk mixed with chloride of lime, which absorbs moisture enough to keep the mass pasty. A charcoal core placed within the hollow carbon electrode absorbs the liberated ammonia gas and thus keeps the cell from polarizing.

The Imchenetzki Battery.

In this battery the exterior containing cell is of tinned iron, with a base of cast iron. The interior cell, open at the base, is of paraffined cardboard, and contains eight porous diaphragms. Melted paraffin wax is poured at the bottom of the first cell, and when this is cold the second is introduced. There are thus nine compartments perfectly insulated, of which four contain sulphite of soda with plates of zinc, and the other five are filled with chromic acid with electrodes of specially prepared compressed graphite. In certain types both electrodes are of graphite. The E. M. F. of this battery is 2.12 volts, or 0.8 volt if both electrodes are of graphite. The battery, when short-circuited, gives a very constant current for several hours.

Engines for Direct Coupling.

To the Editor of The Electrical World:

SIR:—If a simple, durable, high-speed engine, well balanced, cheaper than ordinary engines, and run at a speed of 800 to 1,500 revolutions, could successfully be constructed, would it not be preferable to drive a dynamo from it direct, than to use ordinary engines that belt to the dynamo, the economy being the same?

2. Is the high-speed engine more sensitive in its relations to the action of the governor, than the slow-speed engine?

3. What are the advantages of high-speed engines, and the discarding of belting?

4. What are the speeds of dynamos for the different kinds of lighting? READER.

[1. An engine of the kind you mention should find a ready application for electric lighting purposes. The difficulties that now have to be met, with very high speed engines, are both practical and theoretical. Such engines are apt to give mechanical trouble in various ways; and furthermore, their economy has generally not been satisfactory.

2. Inasmuch as in ordinary forms of governing the change in cut-off only becomes effective at the end of a stroke, the higher the speed of an engine the more chances it gets to govern in a given time, so that, other things being equal, a very high speed engine would have rather the advantage in sensitive governing.

3. There are no very marked advantages in using a direct coupled engine in ordinary central stations. As a rule, belts give comparatively little trouble, and very little power is lost in their use. For special cases, however, a direct coupled engine would be advantageous; more especially in marine and train lighting.

4. The speed of dynamos varies with the size. Very small machines run over 2,000 revolutions per minute; those of the sizes more ordinarily in use, from 800 to 1,200; alternating machines usually a little higher than the latter figure. There is little or no difference in the speed of arc and incandescent machines of the same out-put.

This question of very high speed engines is an interesting one, and we should be glad to hear from any of our readers who have had experience in making or running such machines.—ED. E. W.]

The Spring Meeting of the American Institute of Electrical Engineers.

The annual meeting of the American Institute of Electrical Engineers was held at the house of the American Society of Civil Engineers, 127 East Twenty-third street, New York, May 20. The annual report of the Council was submitted, showing an increase of membership of over 100 during the past year. The increased receipts of the year were $1,260.94, and the increased expenses $855.08. The Treasurer's report showed a balance in the treasury of $249.24. The officers elected for the ensuing year were as follows: President, W. A. Anthony, of Manchester, Conn.; Vice-Presidents, Francis B. Crocker, Frank J. Sprague and Joseph Wetzler, of New York. Managers, P. B. Delany, of South Orange, N. J.; Horatio A. Foster and J. C. Chamberlain, of New York. Treasurer, George M. Pheips. Secretary Ralph W. Pope. The other members of the Council, who hold over in accordance with the rules, are: Vice-Presidents, Edward Weston, of Newark, N. J.; Dr. Edw. L. Nichols, of Ithaca, N. Y. Managers, Charles Cutriss and Geo. B. Prescott, Jr., of New York; Thomas D. Lockwood, of Boston; William Maver, Jr., and Dr. F. Benedict Herzog, of New York; Dr. Wm. E. Geyer, of Hoboken, N. J., and H. C. Townsend, of New York. The vacancies caused by the death of Major Otho E. Michaelis, Vice-President, and the resignation of Henry Van Hoevenbergh, Manager, will be filled by the Council.

Prof. Anthony, the newly elected president, was born in Rhode Island 55 years ago. His education, following the evidently scientific bent of his mind, was completed in 1856 at the Sheffield Scientific School in New Haven. He immediately became a teacher, and, after a short term as principal of a graded school, he was appointed professor of physics at Antioch College. Thence his promotions were first to the Iowa State Agricultural College, and finally to Cornell University, where, in 1872, he was called to take charge of the department of physics. In 1881 Prof. Anthony began the establishment of Cornell's department of electricity; and in 1887 he resigned his professorship to assume the duties of electrician for the Mather Electric Company, of Manchester, Conn.

The total membership of the Institute is now 427, to which 12 were added at the last Council meeting. About June 1st the offices of the Institute will be removed from 5 Beekman to 12 West 31st street, the house recently purchased by the American Society of Mechanical Engineers. An arrangement for the joint occupancy of library and auditorium, with separate offices for the secretaries, will, it is thought, be found very desirable to the members of both societies.

The American Institute of Electrical Engineers will long have occasion to remember with pleasure the first experiment of out of town meetings.

After the annual business meeting in New York, May 20, at which the members had the opportunity of listening to Mr. Wilkes' interesting paper on "Electricity in the Navy," such part of the Institute as could snatch the opportunity migrated to Boston for the regular general meeting. Most of the members left on the midnight train, although a few stragglers had preceded them by the evening boat.

The headquarters of the Institute was at the Hotel Brunswick, directly opposite the buildings of the Massachusetts Institute of Technology, where the meeting was to be held.

On Wednesday morning there was a gradual assembling at the headquarters, and, after a cordial greeting from the Boston members of the fraternity, the Institute repaired to one of the lecture rooms in the Institute of Technology, which had been prepared for its use.

The morning session began at 10 o'clock, and the papers were of more than usual interest. The programme previously laid out for the meeting was not strictly followed. After cordial address of welcome from Gen. Francis A. Walker, president of the Massachusetts Institute of Technology, and response from Professor Thomson, the retiring president of the Institute, the regular papers were taken up. The sequence of the papers was as follows:

"Electric Lighting in the Tropics," by Wilfrid H. Fleming.

"A Study of Arc Light Carbons," by Louis B. Marks, of Cornell University.

"Note on a New Photometer," by Dr. Edward L. Nichols.

"Magnetic Data of the Sprague Street Car Motor," by H. F. Parshall.

In the discussion that followed the various papers, special mention should be made of a brilliant little talk on the electric arc, by Prof. Thomson, indorsing the results obtained by Mr. Marks.

At a little after one the Institute adjourned, and proceeded to the Brunswick, where a photographer was lying in wait, and secured a group of the members present on the steps of the hotel.

After lunch, at about two o'clock, the Institute re-assembled and took up the afternoon papers, which proved to be as interesting as those of the forenoon. First on the list was that on "The Limitations of Steam and Electric Transportation," by Oscar T. Crosby, which had been put down for the morning session, but was crowded over until the beginning of the afternoon.

Following this were "The Industrial Utilization of the Counter Electromotive Force of Self-Induction," by Thomas D. Lockwood, and "The Practical Aspects of Alternating Current Theory" by Dr. M. I. Pupin, of New York.

The session closed with a capital paper and some brilliant experimental demonstrations of "Automatic Electric Welding Machines," by Hermann Lemp, Jr., who has taken an important share in the commercial working out of Professor Thomson's beautiful welding process.

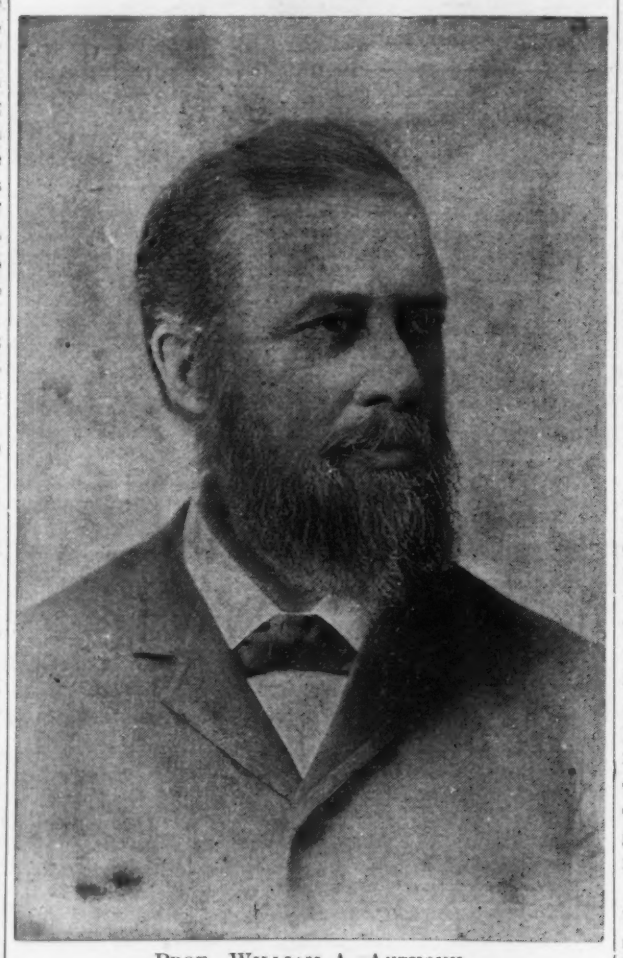
This ended the official exercises of the Institute; but it adjourned only to fall into the hospitable hands of the Boston Electric Club.

At half-past six the club gave a banquet to the Institute at the Parker House, and it would have been hard to find a stronger evidence of the enormous importance of electrical industries than to see the seven large tables surrounded by the active electricians in various departments of practice, and to realize that that large gathering represented only in part the throngs that are to-day intimately connected with the advance of electrical science.

The Boston Electric Club, according to its custom, presented a paper at this, its monthly dinner, and the speaker was Mr. S. E. Barton, well known to every man who heard him, and to the electrical fraternity at large.

President Henry B. Cram, of the Boston Electric Club, presided, and on either side of him were Prof. Anthony the new and Prof. Thomson the retiring president of the American Institute of Electrical Engineers.

Mr. Barton read one of his characteristic, clever papers,



PROF. WILLIAM A. ANTHONY.
President American Institute of Electrical Engineers.

dealing with the "Relations of Electric Lighting to Insurance," and his hits were received with great applause.

Prof. Elihu Thomson was next called up, and the reception that greeted him was sufficient evidence, not only of his commanding position in the profession he represents, but of his wide personal popularity among all with whom he comes in contact.

President Anthony then spoke of the early interest he had taken in electrical industries, and of the efforts that had been made to promote electrical education. He spoke as one having authority, having been almost the first man to recognize the importance of courses leading up to electrical engineering, and himself both a theoretical and practical electrician, who had gone out from a prominent institution of learning, to take a more active part in the development of the great art which his audience represented.

Other speakers followed, among them Assistant Superintendent Dumoulin, of the West End Street Railway System; Capt. Eugene Griffin, Senator Metcalf, E. C. North, chairman of the United States Committee of the Electrical Exchange; Secretary R. W. Pope, of the American Institute, and others. Letters of regret and inability to attend were read by the secretary from President Walker and others, and the very pleasant proceedings of the evening were brought to a close amid cheers between the Boston organization and their guests.

The business of the Institute and the preliminary pleasures having been transacted on Wednesday, on Thursday morning began a day which proved to be one of unalloyed enjoyment for the Institute. The laboratories of Massachusetts Institute of Technology were thrown open at 9 o'clock, and every facility was accorded to the members in examining the facilities for electrical instruction.

At 10 o'clock the West End Street Railway Company took bodily possession of the Institute and did the honors of the system in a way that will long be remembered by those who participated. Carriages were in waiting, and the first point visited was the great power station of the system, which, itself of immense size, is to be followed by a still larger one, the massive foundations of which were being laid at the time of the visit. The power station was of great interest as being the largest and most carefully worked out establishment of its kind for street railway work as yet built, and the plans for the immense extension were of course still more admired by every one interested in the development of electrical railway systems.

After nearly an hour spent in inspecting this station, the party re-entered the carriages in waiting and drove back to the starting point, where special cars of the West End system were ready for a trip over the line to Chestnut Hill. The run was a beautiful evidence of the perfection to which electric railroading has now been brought, and extended through one of the most beautiful portions of the suburbs of the city, running for a long distance over smooth shaven greensward that had replaced the unsightly bare ground of the old horse car days.

On the return from this excurion, the West End Company entertained the party at an elegant lunch at Parker's; after which it released its kindly hold on the Institute, only to turn it over to the Thomson-Houston Company for an excursion to the great Lynn shops.

At 2 o'clock a start was made via the Narrow Gauge Railroad, and at the Lynn station carriages were found waiting to take the visitors to the Thomson-Houston shops. A couple of hours were spent in a most interesting examination of the immense manufacturing facilities of the Thomson-Houston Company. Even in this time only a small part of the work could be examined. The progress of dynamo building was watched from the working up of the rough castings and forgings to the shipping rooms, where the finished machines are ready to be sent out for active service.

The new shop of the Thomson Electric Welding Company proved to be especially attractive, and some beautiful exhibitions of the power and adaptability of the welding machines were given, 2-inch round iron and 2-inch tools being welded with the greatest rapidity and ease. This art is brought to a higher state of perfection in almost every week of passing time, and the members of the Institute were delighted with the results that were exhibited.

Enough could hardly be said of the remarkable interest attaching to the Thomson-Houston works, and even to those of the Institute who were the most hardened mechanicians, there was something fresh and instructive in the exhibition of the very ingenious automatic devices which were in use throughout the works. From an electrical standpoint it is worthy of notice that the power throughout the immense factories is distributed very largely by electro-motors, thus putting into practice the principles and preaching of electricians on a grand scale. A power house is now to be built to furnish light and power for the entire establishment, and if the experience of the company can be put in evidence, the enormous lines of shafting heretofore used in some establishments must go, to be replaced with the much more readily adapted motor.

A little after four o'clock the return trip was made, and the Institute reached Boston with the feeling that it had spent as agreeable and instructive an afternoon as could have been devised for its entertainment.

Then the party broke up, part of it returning by evening boat and part drifting back via various railroads. Every member who participated in the meeting of the Institute, and the subsequent hospitalities tendered by the electrical fraternity of Boston, will long have occasion to remember the meeting as one of the pleasantest events in which they ever had the good fortune to participate.

Among those who took part in the Boston meeting were noticed the following well-known gentlemen:

Ralph W. Pope, Elizabeth, N. J.; A. L. Rohrer, Lynn, Mass.; A. A. Knudson, New York, N. Y; Henry B. Cram, Boston, Mass.; J. P. Wintringham, Brooklyn, N. Y.; George G. Grover, Ansonia, Conn.; A. A. Dion, Moncton, N. B.; Alex. P. Wright, Boston, Mass.; Francis B. Crocker, New York City; A. Floyd Delafield, New York City; O. T. Crosby, New York City; Dr. Louis Bell, New York City; M. J. Francisco, Rutland, Vt.; Charles S. Bradley, Yonkers, N. Y.; Chas. R. Cross, Boston; Edw. L. Nichols, Ithaca, N. Y.; Louis B. Marks, Ithaca, N. Y.; F. A. C. Perrine, Trenton, N. J.; F. L. Pope, Elizabeth, N. J.; R. W. Ryan, New York City; R. N. Bayles, New York City; Kenneth R. Stewart, London, Eng.; Wm. S. Turner, New York City; B. F. Ross, Boston, Mass.; L. S. Dumoulin, Boston, Mass.; Geo. A. Hamilton, New York City; Elihu Thomson, Swampscott, Mass.; George W. Blodgett, Auburndale, Mass.; George F. Curtiss, Lynn, Mass.; George B. Prescott, Jr., New York City; Wm. J. Hammer, Newark, N. J.; Joseph Wetzler, New York City; Edw. C. Caldwell, Boston, Mass.; Richard N. Dyer, New York City; E. W. Mix, Lynn, Mass., Caryl D. Haskins, Lynn, Mass.; John S. Cobb, New York City; C. Wellman Parks, Troy, N. Y.; D. C. Jackson, New York City; Robert J. Pratt, Greenbush, N. Y.; Edwin H. Hall, Cambridge, Mass.; S. Katogi, Japan; John Tregoning, Lynn, Mass.; C. J. Spike, Halifax, N. S.; W. H. Sawyer, Providence, R. I.; H. Lemp, Lynn, Mass.; Herbert H. Eustis, Boston, Mass.; Geo. M. Phelps, New York City; Charles Wirt, New York City; W. H. Blood, Jr.; Lynn, Mass.; Michael I. Pupin, New York City; W. L. Hooper, College Hill, Mass.; J. A. Miller, Providence, R. I.; W. A. Anthony, Manchester, Conn.; Francis E. Jackson, Newark, N. J.; A. C. Shaw, Boston, Mass.; E. Wilbur Rice, Jr., Lynn, Mass.; Otis K. Stuart, S. E. Barton, G. L. Austin, Boston, Mass.; A. E. Dolbear, College Hill, Mass.; W. I. Barker, and Geo. W. Mansfield, Boston, Mass.

The Limitations of Steam and Electricity in Transportation.*

BY O. T. CROSBY.

"Do you expect electric engines entirely to displace steam locomotives on all railroads?" That is a question which has doubtless been propounded to many electrical engineers. Its answer has probably been made. in general, by wise reference to the boundless possibilities of direct production of electrical energy from heat, and to Bellamy's "Looking Backward" storage batteries.

To make some study of the boundary line dividing the province of steam locomotion from that of electric locomotion—under existing conditions of producing electric energy—is the object of this paper.

In the light of present achievements I may state, without argument, the following propositions:

First—It is possible to construct motors capable of doing the maximum work required to-day in transportation.

Second—It is possible continuously to generate electric energy equal to the capacity of any number of such motors.

Third—At any desired loss and over any desired distance it is possible to supply, by the running contact method, the necessary current, at considerable pressure, for the working of such motors.

Should there still be question in the minds of any as to the value of the running contact method at speeds much higher than those commonly used, I may state that I have seen 75 ampères at 500 volts thus continuously supplied to a car moving at more than 110 miles per hour.

These premises being established, further discussion divides itself into three parts.

First, the mere possibility, without reference to economy, of steam and electric propulsion under given conditions.

Second, as to the relative cost of exerting, in a locomotive, any unit of power by electric, as compared with direct steam motors.

Third, as to the relative amount of power required by the two agents to transport a given paying load under given conditions.

In using the word steam, as above, I have in mind only the direct application of steam power on the tracks. The case of cable propulsion is not here compared, as that has, within its restricted field of application, already been compared with horse, steam and electric power.

The limiting possibilities of locomotion may be understood by considering a prolongation of the lines of present practice in the direction, first, of loads handled; second, grades climbed: third, speeds attained; fourth, length of continuous runs.

Since the effect of grade, as compared with line, is simply to increase the tractive effort required for a given load and speed, it need not be separately treated except that there has been some question of increase of adhesion, in the ground return method, which in extreme cases might appear as an advantage for electric propulsion. The matter is not of great importance, and I will refer to it only so far as to say that interpreting my own general experience and some special tests, the adhesion coefficient seems not increased in any practical degree by the mere passage of the current from wheel to rail.

The capacity of an electric engine, like that of a steam engine, to haul any given load, will be measured by the tractive effort possible to be produced and the relation between weight and adhesion for given track conditions. The ready multiplication of cylinders in the one case and armatures in the other, while maintaining mechanical unity as to drawbar division and the ready coupling of distinct locomotive units, renders the whole question of capacity to exert a given horizontal effort, without regard to the time element, unimportant and indefinite.* It goes without saying that, if desired, a single armature may be constructed capable of exerting as great a drawbar strain as any locomotive now in use.

As to limiting speeds, it is not easy to-day to make "an educated guess" either for steam or electric propulsion. The high figures for steam that have been recently presented, both from England and America, are higher than the limiting figures as they would have been given by many competent authorities only a few years ago. Eighty-six miles per hour in England, on the Northeastern Railway, eighty-seven miles per hour in this country on the Reading Railway, have both been reported since Jan. 1, 1890. These runs are noteworthy, not only for the fact of unusual speed, but because, as shown by indicator cards in the English case, and as may be deduced from the consideration of the maximum cylinder power in the American case, the train resistances are far below the values that would have been predicted by even the most liberal of the received formulæ on the subject. The total resistance per ton, as per indicator card in the 86-mile run, was only 13.4 pounds. According to Searle's formula, adopted by Wellington, it should be 69 pounds, engine and tender being taken at 50 tons. The load of 347 tons was carried at 86 miles per hour by an expenditure of 1,068 h. p.—this on a level. The engine was compound.

Would it be possible to attain a speed twice as great, or say 150 miles per hour?

A driver 24 feet in circumference would require to revolve 550 times per minute in order to travel 13,200 feet per minute, or 150 miles per hour—this without slip. Since in the case considered the revolutions per minute reached 309, and since in the Reading case a much higher rate must have been reached, the drivers being smaller, and since on stationary engines a speed much above 550 revolutions per minute has been attained, it seems beyond question that from this point of view the supposed case is quite possible.

Considering the matter of steam supply, we are again brought to consider the whole matter of train resistances at all speeds.

Total resistance to motion should be sharply divided into two classes: the resistance due to motion through air, and that due to friction and blows between vehicle and track and to friction and blows between parts of the vehicle.

For the most part those who constructed the formulæ now found in text-books, worked on roadbeds far inferior to the best work of to-day, at speeds much less than those now attained and with wrong values for at least one of the species of resistance, the atmospheric. On this point I have recently been able to present† as the results of experiments at high velocities, made by Mr. Benj. J. Dashiell, Jr., and myself, a formula showing the pressure to be a function of the first instead of the second power of the velocity as ordinary assumed. A convenient datum point may be given stating that at 100 miles per hour the pressure on one square foot, normal to the direction of motion, is 13 pounds, while proper shaping of the front may reduce this 6.5 pounds.

The absolute values given, while corresponding quite closely with those of received formulæ in the neighborhood of the velocities heretofore experimentally attained, depart widely from those assumed for velocities higher than 30 miles per hour, and calculated by the quadratic relation between velocity and pressure. Using the more trustworthy values, I have been able to separate more nearly than has heretofore been possible the atmospheric from all other resistances met at high velocities. Some inaccuracy still remains, by reason of the difficulty of obtaining exact measure of the resisting areas in a train, but I have been able, by study of careful tests made by others on the N. Y. Central and on English roads, to find that over the range from about 40 up to 80 miles per hour the tonnage coefficient seems practically constant at 8 pounds. This, of course, applies only to first-class roadbed and rolling stock. Whether this coefficient remains constant at higher speeds we do not know. There is no reason to assume, as has often been done, that it increases with the square of the velocity, and on the other hand it will not be safe to assume constancy. From experiments made with a single 2.5 tons car at about 100 miles per hour, the tonnage resistance at that speed seems to be about 20 pounds per ton. Though this value seems quite high as compared with the eight pounds at 85 miles per hour, the difference is in large part to be explained by the poor condition of the track used for the experiment and a constant curvature which would call for about four pounds per ton. Until better evidence can be had it will be safe, at least, to assume a value of 20 pounds per ton, on a first class track, with good rolling stock, at 125 to 150 miles per hour.

Having made this necessary digression, we may return to the matter of steam supply, and state that by reducing weight and area, both to something less than one-half the original values in the 86 mile run, the same effort would produce the speed 150, instead of 86. The area cannot be thus reduced, but by assuming a greater reduction in weight—say to 100 tons, or to little more than engine and tender—maintenance of the higher speed becomes possible, with nearly the same steam expenditure as in the recorded case.

To attain that speed, from rest, might require such original weight of fuel and such length of favorable track as to make the feat practically impossible with steam. This leads us to inquire into the dead weight necessary for hauling say one ton at different speeds.

Form the table of horse-power required for exerting the tractive effort for one ton at various speeds, at various efficiencies, with various values of cross-section per ton, and with the two agents—steam and electricity:

TABLE I.

Columns 1 to 20 inclusive.

Speed.	Tonnage.	Areas exposed per ton in sq. ft.						Rate of work in H. P., 10 per cent. loss.						H. P. at 20 per cent. loss.			H. P. at 40 per cent. loss.		
		1.0	0.75	0.5	0.25	0.2	0.1												
		Horizontal effort.						2 and 3	2 and 4	2 and 5	2 and 6	2 and 7	2 and 8	2 and 3	2 and 5	2 and 8	2 and 3	2 and 5	2 and 8
20	8	2.6	1.95	1.3	0.65	0.52	0.26	0.61	0 58	0.534	0.501	0.49	0.48	0.70	0.07	0.55	0.93	0.8	0.73
40	8	5.2	3.90	2.6	1.3	1.04	0.52	1.56	1.40	1.23	1.068	1.05	0.99	1.77	1.40	1.12	2.37	1.86	1.5
60	8	7.8	5.85	3.9	1.95	1.56	0.78	2.77	2.43	2.09	1.75	1.67	1.54	3.15	2.37	1.77	4.20	3.2	2.37
80	8	10.4	7.80	5.2	2.6	2.8	1.04	4.32	3.70	3.00	2.46	2.35	2.00	4.90	3.50	2.37	6.53	4.6	3.2
100	12	13.0	9.75	6.5	3.25	2.6	1.3	7.32	6.35	5.40	4.45	4.27	3.90	8.32	6.15	4.42	11.1	8.16	5.9
120	15	15.6	11.70	7.8	3.9	3.12	1.6	10.79	9.39	8.03	6.65	6.37	5.84	12.21	9.12	6.66	16.3	12.2	8.85
140	20	18.2	13.65	9.1	4.55	3.64	1.82	15.67	13.70	11.88	10.06	9.75	8.95	17.80	13.50	10 17	23.6	18.0	13.5

Columns 21 to 41 inclusive.

Speed.	Tonnage.	Coal and water for one hour. 5 lbs coal. 15 " water.						Locomotive and tender at 100 lbs. per H. P.			Weight machinery and fuel and weight of load, steam 10 per cent. loss.			Weight load and weight machinery, electric, 10 per cent. loss.			Weight load and weight machinery, electric, 20 per cent. loss.			Weight load and weight machinery, electric, 40 per cent. loss,		
		2 & 3	2 and 4	2 and 5	2 and 6	2 & 7	2 & 8	2 and 3	2 and 5	2 and 8	2 and 3	2 and 5	2 and 8	2 and 3	2 and 5	2 and 8	2 and 3	2 and 5	2 and 8	2 and 3	2 and 5	2 and 8
20	8	12.3	11.66	10.65	10.12	9.9	9.6	61.6	58.3	48.4	73 1927 185	69 1931 164	57 1943 119	1964 36.6 1906	1968 32. 1926	1971 28.8 1941	1958 42. 1894	1964 36. 1916	1967 33. 1933	1944 55.8 1858	1952 48 1888	1956 438 1910
40	8	30.8	27.9	24.6	21.30	21.07	19.8	154	139.7	99	1815 332	1826 285	1881 185	93.6 1834	73.8 1875	59.4 1908	106.2 1811	84. 1858	67.2 1892	142.2 1738	111.6 1808	90 1858
60	8	55.4	48.6	41.8	35.0	33.4	30.8	277	243	154	1668 517	1715 432	1815 252	166 2 1741	125.4 1829	92.4 1880	189.0 1705	142 2 1790	1062 1858	262 1608	192. 1724	142.2 1808
80	8	86.2	73.9	61.8	49 3	47.1	42.1	431	370	210	1483 878	1568 744	1748 477	259.2 1561	18.0 1676	120. 1766	294 1500	210 0 1631	142.2 1735	391.8 1334	276 1510	192 1646
100	12	14.65	131.2	108.2	89.0	84.3	77.8	732	636	389	1122 1293	1256 1099	1523 701	439.2 1354	324 1518	234 1650	499.2 1268	369 1453	265.2 1600	666. 1022	489.6 1268	354 1469
120	15	215.4	187.88	160.	133.0	127.4	116.8	1078	939	584	707 1880	901 1617	1299 1074	646.2 1060	481.8 1287	350.4 1517	132.6 932	547.2 1190	399.6 390	978 584	732 920	531 1190
140	20	313.5	276.0	237.	201.0	195.1	179.1	1567	1380	895	120	383	926	940.2	712.8	483.	1068	810	610.2	1416	1080	810

Columns 42 to 62 inclusive.

Speed.	Tonnage.	Power for one ton freight and car, steam. 10 per cent.			Power for one ton freight and car, electric. 10 per cent.			Power for one ton, electric, at 20 per cent.			Power for one ton, electric, 40 per cent. loss.			Ratio = Steam / Electric 10 per cent.			Steam 10 per cent. / Elec. 20 per cent.			Steam 10 per cent. / Elec. 40 per cent.		
		2 and 3	2 and 5	2 and 8	2 and 3	2 and 5	2 and 8	2 and 3	2 and 5	2 and 8	2 and 3	2 and 5	2 and 8	2 and 3	2 and 5	2 and 8	2 and 3	2 and 5	2 and 8	2 and 3	2 and 5	2 and 8
20	8	0.633	0.55	0.49	0.62	0.54	0.48	0.715	0.68	0.56	0.95	0.82	0.75	1.01	1.02	1.02	0.88	0.81	0.87	0.66	0.67	0.65
40	8	1.72	1.34	1.05	1.63	1.27	1 02	1.88	1.46	1.15	2.55	2.0	1.57	1.05	1.05	1.03	0.91	0.92	0.91	0.67	0.67	0.66
60	8	3.32	2.44	1.70	3.02	2.23	1.61	3.48	2.55	1.87	4.8	3.54	2.55	1.1	1.09	1.0	0.95	0.95	0.91	0.69	0.68	0.66
80	8	5.83	3.82	2.28	4.96	3.3	2.13	5.74	3.91	2.55	8 12	5.34	3.54	1.17	1.16	1.07	1.02	0.98	0.90	0.71	0.71	0.65
100	12	13.05	8.60	5.12	9.38	6.44	4.42	11.08	7.54	5 09	16.6	10.8	7.17	1.39	1.33	1.16	1.17	1.14	1.00	0.78	0.8	0.71
120	15	30.4	17.8	9.0	15.9	10.5	7.08	19.25	12.5	8.35	31.8	19.25	12.0	1.91	1.7	1.27	1.58	1.42	1.08	0.95	0.92	0.75
140	20	260.8	62.0	19.3	295.6	18.46	11.8	38.2	22.7	14.63	80.8	39.1	22.7	8.8	3.35	1.64	7.00	2.7	1.39	3.2	1.6	0.85

Column 1 shows speed in miles per hour from 20 to 140. Column 2 corresponding tonnage coefficient, or resistance, in pounds per ton inclusive of atmospheric resistance. Columns 3 to 8 inclusive show horizontal effort needed for overcoming atmospheric resistance under various assumptions as to area exposed per ton, from 1 square foot to 01. square foot per ton. The former figure corresponds nearly to the case of a heavy locomotive propelling itself alone. As load is put on behind it, other ratios are formed. Oblique surfaces are supposed to be reduced to equivalent normal surfaces. Columns 9 to 14 inclusive show rate of work in horse power per ton, for the various cases of atmospheric and tonnage resistance, as shown by combining columns 2 and 3, etc. Columns 15 to 17 inclusive show h. p. per ton for the extremes and middle cases of exposed area, and for locomotive efficiency of 80 per cent. Columns 18 to 20 inclusive show same for efficiency of 60 per cent. Columns 21 to 26 inclusive show weight of coal and water per ton carried for one hour, assuming 5 lbs. coal and 15 lbs. water per h. p. hour on a steam locomotive. The coal figure is very close to actual practice. The water figure is less, but makes allowance for scooping water at convenient intervals. Continuous scooping is not considered practical or economical. Columns 27 to 29 inclusive show weight of

* Read at the General Meeting of the A. I. of E. E., May 21, 1890.

* As an interesting example of an unusual load in steam service, I may refer to one consisting of 156 loaded cars and two cabooses, hauled over the Mississippi Valley Railway, December, 1885. The load consisted of—

	Pounds.
Cotton weighing	3,226,000
Cars weighing	3,239,000
Engine and tender weighing	147,000
	6,612,000

Speed was about 10 miles per hour.

† An Experimental Study of Atmospheric Resistance. By O. T. Crosby. THE ELECTRICAL WORLD, May 24, 1890, p. 346.

steam locomotive and tender required to generate the required h. p. per ton, under the assumption of 100 pounds per horse power and 90 per cent. efficiency. Only three cases of exposed area are taken; that is, one foot, one-half a foot, and one-tenth of a foot per ton. The weight of steam locomotives is not calculated for any other efficiency figure than 90 per cent., as this seems to be quite constantly attained or surpassed. The assumption of 100 pounds per horse power is closely true for many good types of locomotive when working at speeds from 60 to 80 miles. At lower speeds this figure is too low, but it is assumed that for any ruling speed engines may be built of minimum weight for that speed. In passing through lower than ruling speeds, both electric and steam motors work at low output per pound of weight, hence the assumption of constant weight per horse power will not introduce error materially affecting comparative results. At higher speeds than 80 miles existing engines would show less than 100 pounds per h. p.; but as their boiler capacity is reached at that speed, the necessary increase for any regular work would carry the weight figure to very nearly the figure given for the 60 to 80-mile running. Columns 30 to 32 show weight of steam locomotive and tender, plus weight of fuel and water, per ton hauled, also weight of load-freight and freight car that may be hauled by such weight of motive power; the load figures being obtained by subtracting the motive power weights from 2,000 pounds. Columns 33 to 41 show corresponding figures for electric locomotives under the assumption of 60 pounds per h. p., and at the three efficiencies, 90, 80 and 60 per cent.

The 60 pounds per horse power covers weight of containing car for motors. I cannot here go into detailed figures on this point, but believe that any investigation will find the figure safe, supposing always that the unit be, say, 25-h. p. or more. I also know of experimental work now progressing under most competent direction, which gives fair promise of leaving this figure much too high. Columns 42 to 53 inclusive show the horse power required to be exerted for hauling one ton of *load*, *i. e.*, freight and freight car, the relation between these these two being taken as the same for either steam or electric propulsion, hence not necessary to enter here. These columns apply to steam at 90 per cent., and to electricity at 90, 80 and 60 per cent., and for the three cases of exposed area. They are readily obtained from the previous columns by making allowance for the horse power necessary to haul that part of every ton, total weight, which must go into motive power, machinery and fuel. Columns 54 to 62 inclusive show the ratios between horse power required by the two agents for hauling a ton of *load* (freight and freight car) at the different speeds, efficiencies and area relations.

It is plain that if we can now obtain the ratio of cost per horse power hour, as given by the two agents, in the corresponding cases, we can easily determine the speeds at which the one or the other agent becomes the most economical.

Let us first obtain the cost in electric propulsion.

TABLE II.

ELEMENTS OF THE COST OF ONE H. P. HOUR, ELECTRIC.

Capacity.....	100	300	500	800	1,000	1,500	2,000	3,000	4,000	5,000	6,000
Engineer.....	0.4	0.13	0.08	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Fireman.....	0.3	0,10	0.06	0.037	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Dynamo man	0.4	0.13	0.08	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Helper.....	0.25	0.08	0.05	0.031	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Superintendence..	0.30	0.10	0.06	0.037	0.03	0.02	0.015	0.001	0.001	0.001	0.001
Coal..... ...	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475
Oil, waste & water.....	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Interest and depreciation steam plant	0.057	0.051	0.044	0.033	0.028	0.022	0.022	0.022	0.022	0.022	0.022
Ditto electric plant.. ...	0.057	0.051	0.044	0.033	0.028	0.022	0.022	0.022	0.022	0.022	0.022
Ditto build'ng	0.028	0.026	0.022	0.168	0.014	0.011	0.011	0.011	0.011	0.011	0.011

TABLE III.

TOTAL COST OF ONE H. P. HOUR.

Output in per cent. of capacity while working.	Hours of work per day.	Capacity of Station. 100	300	500	800	1000	1500	2000	3000
100	24	2.42	1.29	1.06	0.9148	0.860	0.835	0.825	0.816
"	18	2.52	1.36	1.115	0.938	0.888	0.855	0.849	0.829
"	12	2.85	1.52	1.228	1.028	0.955	0.95	0 895	0.867
90	24	2.62	1.36	1.12	0 947	0.88	0.86	0.85	0.83
"	18	2.77	1.45	1.17	0.98	0.91	0.88	0.87	0.853
"	12	3.10	1.61	1.29	1.06	0.99	0.94	0.925	0.89
80	24	2.87	1.45	1.18	0.987	0.92	0.91	0.88	0.86
"	18	3.06	1.55	1.23	1.03	0.98	0.936	0.926	0 90
"	12	3.42	1.73	1.37	1.13	1.06	1 0.0	0.98	0.95
70	24	3.19	1.57	1.26	1.04	0.96	0.925	0.91	0 89
"	18	3.42	1.68	1.32	1.09	1.01	0.952	0.94	0.91
"	12	3.82	1.90	1.48	1.19	1.09	1.02	1.01	0.97
60	24	3.62	1.73	1.36	1.11	1.01	0.975	0.96	0.94
"	18	3 85	1.85	1.44	1.16	1.06	1.015	1.00	0.965
"	12	4.31	2.11	1.63	1.30	1.17	1.085	1.07	1.015
50	24	4.22	1.95	1.52	1.20	1 10	1.045	1.03	1.00
"	18	4.50	2.10	1.61	1.27	1.15	1.09	1.076	1.039
"	12	5.09	2.40	1.83	1.43	1.28	1.19	1.17	1.114
40	24	5.11	2.28	1.73	1.35	1.21	1.15	1.13	1.10
"	18	5.47	2 48	1.88	1.44	1.33	1.25	1.23	1.17
"	12	5.20	2.82	2.17	1.64	1.50	1.38	1.35	1.28
30	24	6.63	2.84	2.10	1.59	1.40	1.325	1.30	1.26
"	28	7 08	3.02	2.27	1.71	1.50	1.40	1.38	1.32
"	12	8.06	3.53	2.65	1.98	1.73	1.57	1.54	1.44

For this, form table II., showing the elements in the cost of one horse-power hour in stations of various capacities—from 100 to 3,000 h. p. Engineers and dynamo-men are assumed to receive 40 cents per hour, and to superintend a maximum of 1,000 h. p. This would produce, in some cases, fractional engineers, as for a 1,500 h. p. plant, but such complication has been avoided by assuming a constant value per unit of power, in the pay-roll element in plants exceeding 1,000 h. p. Firemen and helpers are taken at 30 and 25 cents per hour, respectively. Superintendence, at 30 cents per hour, is apparently low, but is equivalent to 60 cents for daylight hours, since the plant is able to run 24 hours with the same general superintendence as for 12 hours. It is further supposed that the total of this item will not require increase until the capacity reaches 3,000 h. p., beyond which it remains constant per unit of power. As no other element of cost is supposed to vary beyond this point, the table shows here a minimum total cost per unit, and a constant cost beyond it.

Coal is assumed to cost $3.00 per ton, and to be consumed at the rate of 3.2 pounds per electric h. p. in the dynamo. A very slight error is made in taking the rate of consumption as constant while changing the capacity of the engines.

Cost of steam plant is taken to vary from $50 per h. p., in a small plant, to $20 in a plant of 1500 h. p. This latter figure may seem too low to some, but I have recently seen the figures for an 800 h. p. plant, in a neighboring Massachusetts city, which cost, in place, at the rate of $22 per h. p.

Dynamo plant is taken to vary from $50 to $20 per h. p. in going from 100 to 1,500 h. p. I know that machinery of good design can be manufactured for these prices.

The cost of buildings is taken to vary from $25 to $10 per h. p. This is the most indefinite item. Interest, maintenance and taxes, are roundly assumed at 10 per cent. per annum on the whole plant.

With table II. as a basis, table III. has been calculated, giving total cost per horse power hour in stations of various capacity, working at various percentages of full capacity and for 24, 18 and 12 hours per day, respectively.

A glance at the table shows that in a 100 h. p. plant the cost varies from 2.42 cents for a 24-hour run at full capacity, to 8.06 cents for a 30 per cent. output continued only 12 hours per day.

This extreme case would doubtless be ameliorated by dropping the superintendence and combining engineer and fireman—though to this the unions might object. This capacity is smaller than need be considered for any steam-line service.

The minimum cost given by the table is 0·816 cents, this for a 3,000-h. p. plant, working full capacity 24 hours per day.

The next element of cost—that of the conductors for the current—is obtained from table IV., showing investment in dollars for the copper required to transmit one h. p. a distance of one mile. at varying initial and final pressures. The constants for this table were thus obtained: taking a well-known line wire, I find that from No. 4 to No. 000 B. W. G., the average weight-ratio of insulated to bare wire, per unit of length, equals 0.884. When bare copper sells at 15 cents, this insulated wire sells at 20 cents = 22.5 cents on the copper alone, when insulated. If, therefore, we take copper at 25 cents per pound we provide for a very good insulation. The cost of one mil-mile is thus found to be $0.004. Combining this with the familiar formula

$$C\,M = \frac{16{,}600 \times \text{h. p. transmitted} \times \text{distance in feet.}}{\text{E. M. F. at motor} \times \text{volts lost on line} \times \text{motor efficiency,}}$$

the tabulated values have been determined from the resulting formula,

$$\text{Cost} = \frac{760{,}320}{(E-V)\,V} \cdot \frac{}{} \qquad (1)$$

in which E = E. M. F. at station, V = volts lost on line, motor efficiency is taken at 90 per cent. and distance at 5,280 feet. The tabular figures give the investment. To reduce to actual cost per horse power hour, rate of interest and depreciation, and ratio between power transmitted, and power possible to be transmitted. For one year the possible horse power hours = 365 × 24. Take annual interest and depreciation at $\frac{1}{10}$ the investment and ratio of actual to possible power transmitted per annum at 1.0, 0.8, 0.6, 0.4, 0.2, 0.1, 0.05, then the divisor of the tabular number becomes 140,160, 112,128, 84,096, 56,064, 28,032, 14,026 and 7,008 respectively.

It remains to obtain values for the distance of transmission.

TABLE IV.—FOR DOUBLE METALLIC CIRCUITS.

COPPER INVESTMENT FOR TRANSMITTING ONE H. P. ONE MILE.

Motor efficiency = 90 per cent.

Initial E. M. F.

Drop on line, volts.	500	1,000	1,500	2,000	2,500	3,000	3 500	4,000	4,500	5,000	5,500	6,000	7,000	8,000	9,000	10.000
100	19.00	8.41	5.42	4.00	3.20	2.60	2.20	1.80	1.60	1.44	1.40	1.28	1.10	0.98	0.84	0.76
200	13.66	4.80	3.42	2.12	1.64	1.34	1.14	1.00	0.88	0.78	0.70	0.64	0.56	0.48	0.42	0.38
300	19.60	3.60	2.12	1.50	1.20	0.94	0.80	0.68	0.60	0.54	0.48	0.44	0.36	0.32	0.28	0.26
400		3 20	1.72	1.20	0.92	0.72	0.60	0.52	0.44	0.40	0.34	0.32	0.28	0.24	0.22	0.20
500		3.00	1.50	1.00	0.76	0.60	0.50	0.40	0.36	0.34	0.30	0.28	0.22	0.20	0.18	0.16
600		3.20	1.40	0.92	0.66	0.54	0.42	0.34	0.32	0.28	0.26	0.22	0.20	0.16	0.15	0.14
700		3.60	1.34	0.82	0.60	0.46	0.38	0.32	0.28	0.24	0.22	0.20	0.16	0.14	0.12	0.10
800		4.80	1 34	0.80	0.56	0.42	0.34	0.30	0.26	0.22	0.20	0.18	0.14	0.12	0.10	0.10
900		8.44	1.40	0.76	0.54	0.40	0.32	0.28	0.22	0.20	0.18	0.16	0.14	0.12	0.10	0.08
1,000			1.50	0.76	0.50	0.36	0.30	0.24	0.20	0.18	0.16	0.15	0 12	0.10	0.08	0.08
1,200			2.12	0.80	0.48	0.34	0.28	0.22	0.18	0.16	0.14	0.12	0.10	0.08	0.08	0.07
1,400			5.42	0.90	0.48	0.33	0.26	0.20	0.18	0.14	0.12	0.10	0.08	0.08	0.06	0.06
1,600				1.12	0.52	0.34	0.24	0.20	0.16	0.14	0.12	0.10	0.08	0.06	0.06	0.056
1,800				2.12	0.60	0.34	0.24	0.18	0.16	0.12	0.10	0.09	0.08	0.06	0.06	0.05
2,000					0.76	0.36	0.24	0.18	0.15	0.12	0.10	0.08	0.06	0.06	0.054	0.046
2,400					3.20	0.52	0.28	0.20	0.14	0.12	0.10	0.08	0.06	0.05	0.048	0.04
2,800						1 34	0.38	0.22	0.16	0.12	0.09	0.08	0.06	0.05	0.04	0.038
3,200							0.78	0.30	0.18	0.12	0.10	0.08	0.06	0.05	0.04	0.034
3,600								0.54	0.22	0.14	0.10	0.08	0.06	0.05	0 04	0.032
4,000									0.36	0.18	0.12	0.08	0.06	0.04	0.038	0.032
4,500										0.60	0.16	0.10	0.06	0.04	0.036	0.030
5,000											0.30	0.15	0.06	0.04	0.038	0.030
6,000													0.12	0.06	0.04	0.032
7,000														0.10	0.054	0.036
8,000															0.08	0.046
9,000																0.008

In using the table it will be convenient to draw curves of equal cost. They will be, roughly, arcs of circles convex toward the left.

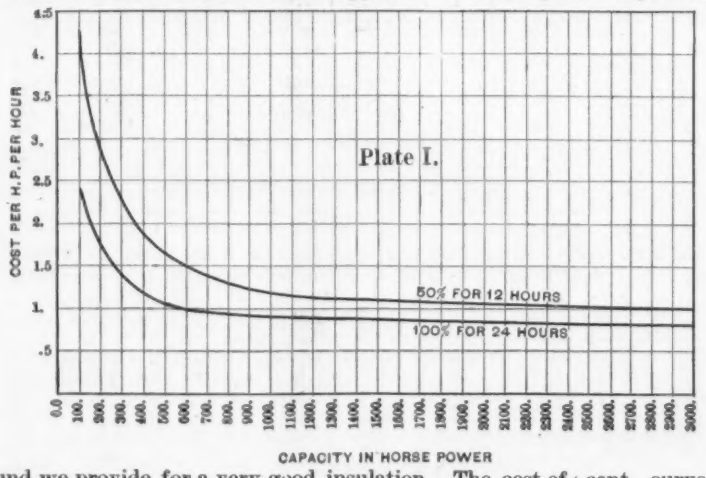


Plate I.

Let n = number of miles of line suppplied from one station.
h = horse power required for unit locomotive.
K = maximum number locomotives per mile at any time.
$n\,h\,K$ = total power to be transmitted at time of K.
A = percentage of dynamo power lost on line.
$\frac{n\,h\,K}{100-A}$ = maximum power to be generated.
$\frac{n\,h\,K}{100-A}\cdot\frac{A}{100}$ = " " lost on line.
b = cost of generating one horse power hour in station.
r = ratio of average power required to maximum power required.
L = interest and depreciation on supporting structure.

This last may be omitted from the calculation, determining division of line into sections, since it remains the same, whatever that division may be. Omitting this, the expression for cost of transmission becomes:

$$\text{Cost} = \frac{760{,}320\,n^2\,h\,K\,r}{(E-V)\,v \times 140{,}160} + \frac{b\,n\,h\,k\,A}{r\,(100-A)\,100}$$

$$= \frac{5.42\,n^2\,h\,k\,r}{(E-v)\,V} + \frac{b\,n\,h\,k\,A}{r\,(100-A)\,100} \qquad (2)$$

Supposing that the time schedule of trains, H. P. required per train, and efficiency of motors be known, and that the initial E. M. F. be in all cases taken as high as the state of the art permits, the only variables remaining in this expression are n, b and A. This latter, the value for the drop on the line, will generally be determined by conditions other than those of strictest economy, as shown by getting a minimum value for cost of transmission. We must have a reasonably uniform E. M. F. all along the line, in order that the motors may work satisfactorily. It will not be wide of the mark to assume 10 per cent. as a limiting variation of line potential. This is the figure generally assumed in calculating wire for street railways.

The cost of one h. p. hour b, must vary with the capacity and conditions of working of the station; hence it is a function of n—*i. e.* length of unit section of A, and of that inexpressible variable—the conditions of the service. This stands in the way of obtaining any perfectly general definite expression for n, which, but for this, would result from placing the first differential coefficient of C, with respect to n, equal to zero, and solving to find the value of n, giving a minimum value for C. If trains be run at very short intervals, increase of n would be followed by proportional increase in capacity of station; but as above shown, this need not go beyond 3,000 h. p. unless the service be so heavy as to require practically contiguous stations of that capacity. If we suppose a case of this short-interval service, so short, that a change in n will not be followed by any change at the station in the relation between maximum capacity and average output, or in the number of working hours, but only in the normal capacity, the relation between b and n for two cases of average output and working hours is shown by Plate 1. The equation of the 50 per cent. curve from 200 to 1,000 h. p. seems to be very nearly

$$b = n^2\frac{-98\,n + 1{,}000}{12\,(n-100)}$$

If the trains be run at very long intervals, we may require no greater station capacity for 20 than for 10-mile sections; but the relation of output to normal capacity will vary, and possibly the number of hours during which the working force would require to be kept on pay.

Taking the case of a change in average output only, for a 1,000 h. p. station, we have the curves in Plate 2, for 24, 18 and 12 hours' work. Their equations are nearly of the same form, and are approximately the equations of arcs of circles referred to an origin outside the circle. But each would contain different constants, and would vary more or less from the exact formula for the circle.

If, in the application to a particular case, the algebraic expression for b, above given, or any other resulting from any of the possible progressions through Table III. be substituted in Equation 2, we may, by differentiation, solve that particular case for the most economical value of n. If the relation between b and n cannot be algebraically expressed, then the proper value for n may be determined by a few trial values, the corresponding values of b being taken from the table.

For the present purposes of comparison, we shall assume a case not more favorable than might often be met on busy steam lines, *i. e.*, a station of 2,000-h. p normal capacity, working 18 hours per day at 40 per cent. of its normal output, the cost per horse power being 1.25 cents.

To obtain the cost of the line, we shall assume that the average distance of transmission is five miles. This would correspond to one station for every twenty miles of road. We shall also assume 5,000 volts initial E. M. F. and 10 per cent. drop. From Table IV. the copper investment is found to be 34 cents for one mile. Then for five miles investment equals $8.50. Making assumptions as to service corresponding to those for the station, we have cost of one horse power hour equaling $8.50 ÷ 20,000 = 0.042 cents.

The structure for carrying the conductors may be built for $2,000 per mile. Interest and depreciation would then become $200 per annum. This total is almost wholly independent of the power transmitted, hence the cost per unit of power will vary directly with the number of units transmitted. Assuming a constant distribution of one 500 h. p. train for every 20 miles of line, we have cost of this item for one horse-power hour:

$$20{,}000 \div 365 \times 24 \times 25 = 0.09 \text{ cents.}$$

Reaching the locomotive, we must add, supposing an average output of 500 h. p., 0.08 and 0.06 cents respectively for driver and his assistant. The latter is necessary only as a substitute for his principal in case of emergency, locomotives is only about three hours. The higher figure results from a smaller number of repairs necessary due to greater simplicity of parts. Then,

$$\text{Interest for h. p. hour} = \frac{50.00 \times 0.05}{365 \times 6} = 0.11 \text{ cent.}$$

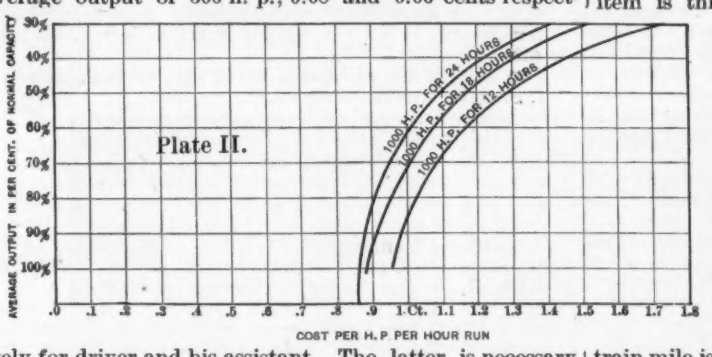
Before summarizing we must know something of the efficiency of the system. If the locomotive be of 90 per cent., or 80 per cent., or 60 per cent. efficiency, we must generate, respectively, 1.25, 1.4 and 1.85 h. p. hours in the station for every h. p. hour actually delivered to drivers, line loss being supposed constant at 10 per cent. We should then have in the station 1.56, 1.75 and 2.30 cents, respectively.

Then, for total:

Station.	1.56	1.75	2.30
Conductor system....	0 04	0.04	0.04
Structure for same....	0.09	0.09	0.09
Wages.....	0.14	0.14	0.14
Repairs.....	0.22	0.22	0 22
Interest.....	0.11	0.11	0.11
Total.....	2 16	2.35	2 90

Of the whole amount, it is to be noted that the station item is three-fourths. Taking the most favorable case shown by the table—3,000 h. p. capacity, working for 24 hours at 100 per cent. of capacity—these figures become 1.5, 1.62 and 2.00 cents nearly, the reductions in the other items being still a little indefinite, without making another series of independent assumptions.

The cost of one h. p. hour excited by steam locomotives is to be obtained only by some circumlocution, the reports of cost being based on train-mile. As quoted by Wellington, the coal consumed per passenger train mile on the Pennsylvania Railroad, is very closely 50 pounds, and on average performance will show 5 pounds coal per h. p. hour, while *under way*. This shows that one train-mile equals 10 h. p. hours. The coal consumption for a freight train mile is much higher, but the divisor would also be higher, on account of the greater number of stops, or at least of backing and switching, and greater delays while on a trip, thus increasing waste of coal.



Again, the Pennsylvania Railroad reports show cost of fuel per train (mile) 5 cents. The cost of coal to that company, as nearly as I can learn, is about $1.50 per ton. Hence it would appear that 66 pounds per train mile are consumed. As the terminal losses of fuel and delay (getting up steam and drawing fires, etc.) are known to be in the neighborhood of 25 per cent. of the total consumption, we have 6.6 pounds as the divisor, and the same ratio again appears.

The cost of one train mile—as to motive power alone—is given by the Pennsylvania Railroad as 22 cents. And this is practically equal to the average for the North Shore. The itemized statement is very carefully made up, and seems to cover everything except interest on the engine investment.

Knowing the annual mileage per locomotive to be about 20,000 and the cost to be $10,000, interest charge per train mile (not quite, but nearly equivalent, to engine mile) becomes 2.7 cents. Total cost becomes 24.7 cents, or 2.47 cents per h. p. hour, efficiency being constant at 100 per cent.

We may safely use this figure in the comparison to be made, since any positive error in the calculation of coal per h. p. hour, or negative error in h. p. hours per train mile, will be offset by the difference in cost of coal per ton to the P. R. R. as compared with the value assumed in table III.

At $3, instead of $1.50, the full item would be 10 cents and the total motive power 29.5 cents. Leaving the statistics of actual cost, we may reach, by the method of table III., nearly the same figure, considering the locomotive as a 1,000 h. p. steam plant, of low first cost, burning 6 lbs. coal per h. p. hour, and working at one-third capacity for about three hours per day. The result thus reached is about 10 per cent. higher, but the 2.47 cents seems most trustworthy.

These values multiplied into the corresponding values in the last nine columns of Table I, give the following values of:

$$\frac{\text{Power units, steam}}{\text{Power units, electric}} \times \frac{\text{cost per unit, steam.}}{\text{cost per unit, electric.}}$$

This value being greater than unity indicates greater economy by electricity than by steam, and vice versa.

TABLE V.

RATIOS OF COST OF MOTIVE POWER.

Efficiency of electric engine.	10 per cent.			20 per cent.			40 per cent.		
Tonnage and area relation.	2 & 3	2 & 5	2 & 8	2 & 3	2 & 5	2 & 8	2 & 3	2 & 5	2 & 8
Speed.									
20	1.15	1.16	1.16	0.92	0.85	0.85	0.56	0.56	0.55
40	1.19	1.19	1.17	0.95	0.95	0.95	0.57	0.57	0.56
60	1.25	1.24	1.19	1.00	1.00	0.95	0.58	0.58	0.56
80	1. 3	1.32	1.22	1.07	1.03	0.94	0.59	0.59	0.57
100	1.58	1.42	1.32	1.23	1.20	1.05	0.66	0.65	0.59
120	2.57	1.94	1.47	1.66	1.49	1.13	0.80	0.78	0.64
140	10.03	3.82	1.87	7.35	2.83	1.46	2.72	1.36	0.72

A glance at the table shows the dominating necessity of increasing the efficiency of the mechanism delivering energy from the electric line to the vehicle. We cannot count upon a higher efficiency than 90 per cent. for the motor. Hence, save in the case of putting the armature directly on the axle, we cannot hope to reduce the total loss to less than 20 per cent.—a case permitting one set (*i. e.* two gears) of spur gearing between armature and axle. As the ordinary relation between tonnage and resisting area will lie between the second and third columns of each efficiency table, it appears that with a 20 per cent. loss electricity becomes cheaper than steam at about 70 miles per hour.

In the case of 40 per cent. loss our new agent betters the old only at 140 miles per hour. And yet this loss—40 per cent.—is about the best we do with our present systems of electric propulsion. This appears from the following tabulation of results obtained by me on the Brooklyn & Jamaica Electric Railway.

Considering the very short life of the art, these results are excellent. Indeed, excellence is shown in the mere fact of success in competing with horses under conditions very

TABLE VI.—FIGURES ON STREET-CAR TRACTION. TRACK NEARLY LEVEL.

Date.	Designation of motor-car.	Weight of motor-car and passengers.	Weight of towed car and passengers.	Length of trip in miles.	Average speed, miles per hour.	Potential at station, volts.	Ditto at car, average.	Current in motor "A," amperes.	Current in motor "B."	Current in trolley wire of car.	Difference of "A" and "B."	Number of readings averaged.	Corresponding time interval, seconds.	Total average energy in car, in H. P.	Horizontal effort req'd per ton, in pounds.	Corresponding mechanical H. P.	Hysteresis, eddy currents and friction in armature "A," watts.	Ditto in armature "B."	C²R loss in "A," watts.	Ditto in "B."	Total loss in motor or motors, H. P.	Total gearing loss, H. P.	Efficiency of motor or motors.	Ditto of gearing, one or two sets.	Ditto of motors and gearing.	Record number of run.	Remarks.
April	No.	Pounds.		3.5 and return, 7.0							A and B assumed equal except when difference was measured.																Track this day rather dirty. Tonnage co-efficient taken 10% higher than Apr. 20, when observations were made.
3	6	12,000	0		9 3	480	440	6.63	6.63	13.27		262	10	7.63	27.5	4.09	550	550	88	88	1.71	1.83	77.4	69.0	53.6	1	
3	6	12,000	0	2.84 and return, 5 78	10.45	480	440	7.6	7.6	15.2		185	10	8.92	27.5	4.6	600	600	115	115	1.97	2.4	78.0	65.7	51.5	2	
3	8	12,000	0	2.84 and return, 5.78	11.5	480	440	11.85	0	11.85		145	12	6 96	27.5	5.06	675	0	230	0	1.2	0.7	82.7	87.8	72.7	3	Armature of motor "B" taken out for this and trip No. 4.
3	8	12,000	0	3.5 and return, 7.0	9.1	480	440	10.0	0	10.0		230	12	5.87	27.5	4.0	550	0	200	0	1.0	0.87	83.1	82.1	68.0	4	
20	8	11,850	6050	2.84 and return, 5.78	10.0	480	440	7.85	7.85	15.7		144	15	9.25	25	6.0	600	600	123	123	1.94	1.31	79.0	82.0	64.8	5	Dynamometer between motor and tow car. 131 readings taken.
20	8	12,000	7200	2.84	8 3	480	440	12.26	0	12.26		85	15	7.23	25	5.31	500	0	300	0	1.07	0.85	85.2	86.0	73.0	6	Motor "B" cut out of circuit.
May				2.84 and 3 5																							
2	8	12,400		6.34	10.9	480	440	7.68	5 52	14.2	1.16	131	15	8.37	25	4.5	650	650	118	61	1.98	1.89	76.3	70.4	53.7	7	Separate ammeter in each motor circuit and in main.

NOTE.—Voltmeter readings taken April 3 and 20, assumed same values May 2. Traction co-efficient also taken from April 20, as track was in same condition. Losses in motors cannot be given with perfect accuracy, as they have not been determined for wide ranges of condition by shop tests. Values for hysteresis, etc., here taken correspond closely with several shop tests. Except C²R, motor loss does not vary largely with current flowing in practice, as with a low current, a very large armature induction is effected. The "R" in C²R cannot be known accurately, as it constantly changes with change in position of switch. A fair average of switch position was obtained from observation. Total error in motor losses probably not greater than 10%. Run No. 7 not introduced here for discussion of difference of action of motors "A" and "B:"

Average efficiency whole mechanism, two motors = 55.9 per cent.
" " " " one motor = 71.2 "
" " one motor alone ..... = 83.6 "
" " two motors " ..... = 77.6 "
" " two sets gears alone ..... = 71.8 "
" " one set gears ..... = 85.3 "

but as such he would doubtless always be placed on trains of considerable value.

Repair on electric locomotives is not as yet well defined. That the repair bill must be far less than in the case of steam locomotives follows almost necessarily from the great reduction in the number of parts, especially of moving parts.

From Mr. Arthur Wellington's very valuable work on railways, I take the figures showing percentage distribution of locomotive repairs, by parts.

Boiler, 20 per cent.; running gear, 20 per cent.; machinery, 30 per cent.; lagging and painting, 12 per cent.; smoke-box, etc., 5 per cent.; tender (running gear, 10 per cent.; body and tank, 3 per cent.), 13 per cent.; total, 100 per cent.

Of these items we may at once, and with certainty, strike out boiler, smoke-box, etc., and tender, thus dropping 38 per cent. of the total. Having no boiler to carry the running gear will be less in quantity.

The wear will be less, due to the use of rotary instead of reciprocating effort. It will then be fair to reduce this item by half, making another saving of 10 per cent. So in the machinery item, there can be no question that with the rapid advance toward slow-speed motors, reducing gearing, and sounder insulation methods, the great advantage of having only *one moving part* in the motor itself must operate very largely to reduce the repair figure, probably to half its value in a steam locomotive, leaving it at 15 per cent. In lagging and painting the omission of boiler and other parts must again effect a reduction, say to 6 per cent. The total reduction thus plainly indicated must be then very nearly 70 per cent.

The actual cost of repairs to-day on steam locomotives is, on the P. R. R. nearly 0.75 cents per h. p. hour, as will later appear. Reducing as above, this figure becomes 0.22 cents for electric traction. This refers to engines of considerable power, say from 400 to 1,000 h. p. capacity. The figure for both steam and electric locomotives would go up for smaller powers.

The interest charge results from considering the cost of an electric locomotive as $50 per h. p. and the duty as six hours per day full capacity. The average duty of steam

trying for any mechanism not made of india-rubber or leather. How great that success has been I need not here proclaim. But the steam locomotive is a foeman more worthy of our steel, or rather of our annealed soft iron and 99 per cent. copper.

Consideration of all that precedes leads to the following general conclusions:

1. A slow-speed armature placed on the car axle would place the electric motor in the lead at all service speeds.

2. For speeds above 70 miles per hour an electric motor of 90 per cent. efficiency, working through gearing of 90 per cent. efficiency, would prove more economical than the steam locomotive—save in cases of very infrequent service on very long lines.

3. On lines for heavy traffic steam would be more economical than electricity if motor and gearing have a combined efficiency as low as 60 per cent., up to 100 miles per hour.

4. At speeds of 100 miles per hour and upward, neither steam at 90 per cent. nor electric apparatus at 60 per cent. efficiency is commercially practicable.

5. Inasmuch as the saving of coal in stationary, as compared with locomotive engines, is one of the chief causes of the greater economy of electric propulsion, at any speed, this advantage will increase with that difference and also with the price of coal.

6. Any cause other than inefficiency of motor which increases the power required to haul a ton of freight, increases the advantage of electricity, since it enlarges the value of the coal difference and the dead-weight difference.

Thus bad roadways and large areas exposed to atmospheric resistance, as in street railway work, lower the speed at which electric motors of any efficiency become cheaper than steam.

7. In descending to small locomotive units, the electric motor loses less, relatively, of its advantage—another reason for success on street lines.

8. Multiplying the number of motors should be as far as possible avoided.

9. In special cases cleanliness and compactness of electric machinery may be of great value; in case of very frequent stops the possibility of returning to the line the

energy now wasted in brakes may be of considerable value. This, however, can be obtained only by sacrifice in the matter of dead-weight, as normal working is implied to be at comparatively low magnetization. Loss due to low efficiency in starting can scarcely be avoided either in steam or electric engines.

10. Other minor pros and cons might be enumerated, but I believe that in considering the general economic results of the two sytems we reach more definite conclusions.

While only one condition of station working has been taken for final comparison, that case is an average one, and comparative results would be but slightly affected by ordinary variations. Extreme cases may be readily determined from the tables and formulas presented.

11. Some differences of opinion as to the proper values for the various constants are to be expected, but I believe these differences, taken all along the line, would nearly balance between positives and negatives, leaving the general results and the method unchanged.

Electricity in the Navy.*

BY GILBERT WILKES, U. S. NAVY.

I have taken as my title "Electricity in the Navy," and shall give in my paper the general conclusion derived from five years' more or less intimate connection with the application of electricity in our naval service.

The electrical engineer has little to do with the placing of the dynamo room, which is of necessity governed by the arrangement of the ship as a fighting machine. I shall, therefore, merely consider the power and apparatus of the plant, commencing with the engines.

Both in this country and abroad compound condensing engines have been used, some having separate condensers, some exhausting into the main condensers of the ship, but the preference seems to be in favor of simple double-acting, high-speed engines, the reason being that the power used for electrical purposes is so small in proportion to that of the main engines of the ship (only about an average of one per cent.) that the saving does not pay for the additional complication and cost. However, with a given plant, the engine should be constructed to allow little variation of speed under large changes of steam pressure, in order to take advantage of the main condenser when possible.

In our service both horizontal and vertical engines are now in use, the preference in some cases being the result of the shape of the available space. No data have yet been obtained as to the most economical type, but both are doing good service, the mishaps having been due to accidents. Of late years all the engines put in for electric lighting have been high speed, the largest of about 25 h. p. and running at 400 revolutions.

The important points in the consideration of a marine dynamo are:

First—It should be direct driven. The reasons are obvious, as, not only is the space taken up by the belting valuable, but in a sea way the danger of running belts must be considered, especially when it is taken into account that naval vessels are fighting machines and the possibility of accidents must be reduced to a minimum.

Second—It should be compact. This is a natural extension of the above. Even now it is difficult to find room for all of the machinery, stores and ammunition, besides providing room for berthing the crew on a modern man-of-war.

Third—It should be free from liability to injury by salt water, and not too subject to mechanical damage.

In this respect there remains room for considerable improvement, the latest dynamos now better filling this requirement than did the old "L" machine on the Trenton in 1883, the first dynamo afloat in our Navy, and which ended its useful career in the great storm at Samoa last year, when it ran until the water had put out the fires under the boilers.

On board ship salt water and damp air get everywhere, and within the last year a number of cases of slight burnout have occurred in armatures, which, when installed, measured high in the hundreds of thousands of ohms insulation. The dynamo should not be easily harmed. The dynamo room is now always low down in the ship, under the protective deck (if there is one), and when the light is not in use the room is very dark, rendering careful inspection difficult.

Fourth—The dynamo should have small effect upon the compasses. This point has received little attention, though it is a matter of great importance, as the effect on many vessels is so large that, in order to work up the day's run, it is necessary to know the hours during which the dynamos have been in operation. Complete deviation tables are therefore necessary for the two cases. In different types of dynamos the effect with a 20 h. p. machine, at a distance of 12 feet, will vary from less than one-twentieth of the horizontal component of the earth's magnetism to several times the strength of the horizontal component. The latter is, unfortunately, rather the rule than the exception, and, in consequence, the position of the dynamo room has to be well borne in mind in locating the standard compass.

Fifth—It should be easy in running and require but little attention. The machine should be non-sparking, under constant load, and also be able to stand sudden large changes of load with little sparking. This is necessitated by the fact that the dynamos now supplied for incandescent lighting are also used for search-light work, and the conditions are aggravated by most of the search lights having hand regulation only. Thus, with a 200 ampère machine, not only are from 50 to 100 ampères thrown suddenly on and off, but, at the moment that the operator at the projector brings the carbons together, the dynamo is suddenly called upon to deliver over three-fourths of its total capacity.

Sixth—It should be efficient and run cool, the former in order to avoid the waste of energy and a corresponding amount of the coal supply, and also in order to avoid overheating. The dynamo rooms on shipboard are, at best, warm, notwithstanding the motor fans, which are now usually supplied, and thus the safe limit of extra heating is reduced. At the same time consideration for the attendants requires that the cramped space be kept as cool as possible.

Seventh—The dynamo should maintain a constant potential at all loads. This is of course accomplished by compounding, and as there is only about three per cent. drop, it is usual to compound exactly or to only over-compound enough to allow for the decrease in the engine's speed with load

Eighth—The dynamo should be light. The reasons are obvious, but it is considered last because usually a careful study of the materials and arrangement of the plant can accomplish more toward reducing the total weight than the strict adherence to a specification of watts per pound of dynamo. Thus, consider the difference between the weights of a 40 h. p. ship plant on a five watts per pound specification, and upon a four watts specification. Two 200 ampère, 80 volt dynamos, with their share of the bed plates, will only weigh about 7,500 pounds. Twenty per cent. of this will be 1,500 pounds, an amount a large portion of which can really be saved in some cases by more careful attention to the amount of wire and molding employed.

Naturally no one dynamo can best fill all these conditions, and while the order in which they are above arranged will usually approximate to their relative importance, special cases arise which demand re-arrangement. Thus, on torpedo boats, the most important quality is small size. With this in view, numerous devices have been placed upon the market and faithfully tried, but none have to my knowledge proved satisfactory. The requirements of high efficiency, low speed and low heating all give way in this class of dynamo to the necessity of compactness and light weight. Good results were hoped for from the Parsons turbo-electric generator, but experience at Newport demonstrated that the turbine was so inefficient in its consumption of steam as to place its use out of the question. There is as yet no apparatus to satisfactorily fill this want.

Up to the present all of our ship plants contain two or more similar sets, each composed of an engine and one direct-driven dynamo. The larger of these are of 200 ampères capacity; a very convenient unit, but one which can be doubled in capacity with advantage in ships which are not light below decks and which are likely soon to have extensive motor applications, for example, vessels of the monitor type.

The voltage in use in the Navy is eighty volts, this having been fixed upon as a mean between the most efficient pressure for the incandescent system and the voltage necessary for the search lights, to which current is supplied by the regular service machines. The incandescent lamps have given excellent results as to life from the very start, owing in great measure to the fact that low efficiency lamps are always used, nothing more economical than four watts per candle power being usually required.

Search lights of fifty volts and from fifty ampères up are used, two or more being supplied, according to the size of the ship. Some of these are imported, others are made in this country.

The two-wire system has always been used in the naval service, the ship never being allowed to form the return circuit. On account of the present beginning of motor work on board ship and the future developments confidently looked for, the direct current has always been used. Motors have thus far been used only in driving small fans up to one-half horse power, for hoists, and in one case, a motor has been used for training one of the large guns on the "Chicago." There are numerous small engines about a man-of-war, varying from one to fifty horse power. Some of the smaller ones might, even now, be replaced with advantage by electric motors, but it must be proved in each case that the motor not only does the duty as well as the engine it replaces, but also that it and any increase necessary in the generating plant take up less room and weigh less than the engine and its piping. This, of course, will always be the case where very small engines are replaced, and, as the tendency is to increase the capacity of the dynamo plant, it may not be long before motors may look for a larger field on board ship.

All circuits are water-tight from dynamo to point of distribution, the cut-outs having stuffing boxes through which the lead-covered wires enter. Even the switches and attachment plugs for portables are required, in certain places, to be water-tight.

One electrical application that presents many advantages on board a man-of-war, especially when on a foreign station, is electrical welding. However, when it is introduced on shipboard, the pressure of the generator should be reduced to 80 volts, in order that in case of emergency it might be used for lighting purposes, while the welders should have several sets of adjustable clamps. Welding machines have not yet been actually used on shipboard, but it is to be hoped that their introduction is a development of the near future. They cannot supplant any of the existing dynamos, owing to the necessity of motors, but must come in to occupy a place of their own, to almost entirely supplant the ship's forge and add to the general useful equipment.

Thus the man-of-war is the proper field for nearly every form of application of electricity, and when the storage battery becomes more suited to the service there required, there is no doubt that it, too, will come in for its proper share of usefulness.

As to the naval work on shore in the electrical field little need be said, as the practice at naval stations must be similar to that in ordinary commercial work. However, a navy yard is an ideal place for the erection of a central station for light and power. The streets must be lighted; closely grouped about the station are offices and large shops needing light in the dark afternoons and power for motor work; then in an outer approximate semi-circle lie the officers' quarters; finally there are anchor chains to be welded, boiler tubes to be repaired, and numerous other similar operations which can be better accomplished by the welder than by any other known means. This in an ideal plant will call for arc lights, incandescent lights, constant potential motors, a welding generator and welders. The complete combination will probably not be realized at any one place within several years, but a good beginning has been made in the arc light plant recently installed for outside and shop lighting at the Washington Navy Yard, and the progressive plan adopted by the Department leads us to hope that the shore stations will rapidly receive the benefits already enjoyed on shipboard. Owing to the usually close grouping of the buildings and to the demand for motors, it is probable that in only exceptional cases will the alternating current be used extensively. Good use is already being made of small motors for drilling purposes at the New York Navy Yard, where several are in constant operation, having driven out the portable steam engine, countershafting and belting.

The applications of electricity in the navy have always been on the increase, and any one who has served one cruise with oil lamps and one with electric lights and motors will understand the favor in which the increasing use of electricity is held by the naval men.

*A paper read before the General Meeting of the American Institute of Electrical Engineers, May 20, 1890.

Life and Efficiency of Arc Light Carbons.*

BY LOUIS B. MARKS, M. E.

From the experimental stage of arc lighting to the commercial application of the system to-day, little or no increase in the efficiency of the carbon points appears to have been made.

Now that our dynamos and lamps have reached such a state of perfection, the subject presents itself as pre-eminently important. The arc light pencil, considered as an individual part of the plant, is indeed a small thing, but in it undoubtedly lies the weak spot of the system.

It was with a view of studying the action of modern carbon pencils that the investigations here to be described were undertaken. The carbons experimented upon were all of American manufacture, and were procured from five companies (A, B, C, D and E).

While the greater part of the research was upon the life and efficiency of the pencils, observations were also made in other directions.

The subject will be treated under the following heads:

1. Structure of the carbons.
2. Life tests.
3. Efficiencies.
4. Candle-power measurements.
5. Observations of the arc and carbon points.

It is well known that the life and efficiency of a carbon depend upon the system in which the latter is burned. For instance, "the requirement of the low-tension system seems to be a carbon that is hard, well plated and a good conductor, the latter being the most important.

"In the high-tension system, on the contrary, hardness and conductivity seem to be of secondary importance. There is a tendency to 'flame' and burn unsteadily, when a hard carbon is used in this system, and a softer one sometimes becomes necessary." †

It is interesting to note the methods employed by carbon manufacturers to attain the conditions above mentioned. In one of our largest carbon works, "forced" carbons, or those made by "squirting" the plastic material through a die, are manufactured for both high and low tension systems of lighting, to the exclusion of molded pencils. On the other hand, another company makes no forced carbons, but claims that its molded pencils are superior for either system. From the classification given below can be seen the types of carbons now upon the market for both systems.

Carbon.	High tension.	Low tension.
A	molded	forced
B	"	molded
C	"	"
D	forced	forced
E	molded / forced	"

One of the first things that suggested itself was the study of the structure of the various samples submitted.

For this purpose, thin transverse sections of all the specimens were cut and mounted on glass slides, and a microscopical examination made.

The accompanying photographs (Figs. 1–12) show the appearance of the carbons under a magnifying power of about forty diameters in the case of groups A, B and C, and about eighty diameters in that of D and E. While the views cannot give either the color or lustre of the original, they are mainly useful in conveying an idea of the texture of the surface.

Examining the photographs, we note that there is a marked difference between the structure of a molded and a forced carbon. In the high-tension pencil of the brand A, (Fig. 1) the structure is a loose one, while the low-tension rod of the same group is marked by a dense homogeneous structure; the size of the grains of carbon in the latter case is very much less than in the former, and as seen under the magnifying power of the microscope, the particles have a more metalloid lustre. Again, there is probably considerable air space in Fig. 1.

Thus it appears that Fig. 1 has the qualifications of a high-tension carbon, *i. e.* looseness of structure, hence comparative softness and high resistance; and Fig. 2 the requisites of a low-tension pencil, *i. e.* density, hardness and low resistance. The resistance of the rod (Fig. 1) was measured and found equal to .199 ohm; that of Fig. 2 equalled .144 ohm. The resistance of the plated low-tension carbon was .084 ohm.

The structure of the carbons in group B (Figs. 3 and 4) was found after close examination to be about the same. To secure the requisite low resistance of Fig. 4 the pencil was heavily copper plated, the thickness of the coating being about $\frac{1}{10}$ millimetre, while that of Fig. 3 was a little less than $\frac{1}{20}$ millimetre.

A method different from either of those just described is used in the manufacture of carbons C (Figs. 5 and 6). As in the previous instance, molded carbons are made by this company for both high and low tension systems, but a much greater pressure is applied to the molds in manufacturing low-tension pencils than in the case of high. This accounts for the difference in structure exhibited in the photographs; although a molded carbon, Fig. 6, thus approaches the structure of the forced pencil, Fig. 2.

Groups D and E are highly magnified. An attempt has been made to manufacture a carbon that will burn fairly well in either system. Fig. 8 shows this carbon. In structure it is a mean between Fig. 7 and Fig. 9. Besides a difference in pressure used in constructing pencils of group D, there is also a difference in the "mix" or composition of the carbon.

The dissimilarity in structure between carbon E, Fig. 11, and E, Fig. 12, is apparent, yet both pencils are used in high-tension systems. The efficiency of these types, as well as of the others, will be discussed later. Fig. 12, it will be noted, is very similar in structure to Fig. 9 (carbon E); in both cases the striations are marked and indicate that the carbon is built up of strata lying longitudinally, or in the same direction as the application of the pressure used in manufacturing the pencils. When examined with the microscope, carbon D (Fig. 9) evinced more lustre than

*Read before the General Meeting of the American Institute of Electrical Engineers, Boston, May 21, 1890.

†See "What Constitutes a Good Carbon Point." By G. W. Parker. THE ELECTRICAL WORLD, March 3, 1888, p. 112.

Fig. 12, showing that a greater quantity of pure carbon was used in the manufacture of the former.

LIFE TESTS.

If a carbon is burned with a small current its life will be long at a sacrifice of light-giving properties. If, on the other hand, a large current is used, there may be a gain in efficiency at a sacrifice of life. The question arises, What is the proper current to use? Of course circumstances determine to a large extent the answer, and generally such a current is used as gives a fair mortality at a reasonable efficiency of the carbon.

The high-tension carbons submitted for test were designed to be burned at about 10 ampères and the low tension at about 20. In the life tests a Thomson lamp was used for high-tension runs, current being kept constant at 10 ampères and P. D. at 50 volts. For low-tension carbons the Weston lamp was used. The pencils were accurately weighed before and after the runs, and the life calculated on the assumption that the carbons were homogeneous. Each set of pencils was burned an hour. The results of tests are given in table I.

It has been stated that "with carbons of the same *hardness* and length, but varying diameters, the larger will undoubtedly outlive the smaller. Of carbons of the same *diameter* and length, but differing in hardness, the harder will outlive the softer."*

This statement presupposes that the conductivity of the carbon is directly dependent on the hardness or softness of the pencil.

TABLE 1.
LIFE TESTS.

CARBON.	Mean diameter, inches.	Resist., ohms.	Initial wt. + grms.	Initial wt. − grms.	C. ampères.	P. D. volts.	Loss in wt. + grms.	Loss wt. − grms.	Life 12 inch÷carbon hours.
A molded high ten. (naked)	.502	.199	59.87	25.10	10.	50	5.86	3.59	10.22
A forced low ten. (plated)	.500	.072	64.89	27.16	21.5	30	6.15	4.43	10.55
B molded high ten. (plated)	.505	.075	58.17	28.32	10.	50	4.80	2.44	12.12
B molded low ten. (plated)	.498	.071	367.80	295.50	22.5	28	166.60	51.50	9.42*
C molded high ten. (naked)	.510	.2165	62.94	29.03	10.	50	6.21	3.63	10.13
C molded low ten. (plated)	.515	.0715	594.40	294.50	22.5	28	151.00	41.0	9.83*
D forced low ten. (plated)	.506	.095	62.46	36.10	21.5	30	6.92	3.08	9.03
D forced high or low ten (plated)	.504	.142	60.58	29.78	10.	50	6.63	4.16	9.11
D forced high ten (naked)	.457	.187	47.20	23.53	10.	50	5.46	3.29	8.64
E forced low ten. (naked)	.505	.2207	344.68	244.64	22.5	28	193.18	74.42	7.71*
E molded high ten (naked)	.533	.202	63.30	30.48	10.	50	6.09	3.04	10.39
E forced low ten. (naked)	.522	.251	59.62	29.81	10.	50	5.91	3.52	10.09

* These low-tension runs were made with the Weston plant on the University Campus. Ten lamps were run in series. Time of test was 2½ hours in the case of carbons B and E, and 2 hours and 25 min. in the case of C.

In order to examine more fully the relation between diameter resistance and mortality of a pencil, six sets of carbons of the brand B, varying in diameter from ¼ to 1¼ inches, were carefully weighed, their resistances measured by the Wheatstone Bridge method; and the pencils burned with a constant current of 10 ampères from a Gramme dynamo, the P.D. at the intervals of the lamp being kept at 50 volts. The diameters and resistances respectively of the upper and lower carbons were in each case practically the same. A mean of ten micrometer measurements of the diameter was taken as correct. The duration of each run was 60 minutes.

Following are the data:

TABLE 2.
MORTALITY WITH DIFFERENT DIAMETERS.

CARBON.	Mean diameter, inches.	Resist., ohms.	Initial wt. + grms.	Loss wt. + grms.	Life 12-inch ÷ carbon hours.
B molded high ten.	.453	.0805	44.70	4.20	10.64
" "	.505	.075	58.17	4.80	12.12
" "	.618	.0735	94.93	6.96	13.64
" "	.739	.0615	132.34	6.19	21.38
" "	.986	.061	232.20	8.88	26.15
" "	1.195	.059	339.57	10.14	33.49

From the results given in Table 2, it appears that the life of a carbon varies *directly* with its *diameter* and *inversely* with its *resistance*. This law holds only for homogeneous carbons of the same manufacture, type and structure, and, as stated before, for constant current and voltage.

Let us take the ½ inch (.505″) and one inch (.986″) pencils as standards, and from the relation above stated calculate the mortality of the other carbons.

Table 3 gives a comparison of the actual and the calculated life of the various specimens tested.

TABLE 3.

CARBON.	Mean diam., inches.	Standard = ½″ (.505″) Calculated life hours.	Standard = 1″ (.986″) Calculated life hours.	Actual life hours.
B molded light..	.453	10.92	9.32	10.64
" "	.618	15.10	13.62	13.64
" "	.739	21.58	19.44	21.38
" "	1.195	36.50	33.04	33.49

Thus it appears that the calculated life throughout the series is larger than the actual when the ½-inch carbon is taken as a standard, and smaller when the 1-inch pencil is made the basis of calculation.

The carbons of group B were not perfectly round, a variation of three degrees being at times found between the ten measurements of the diameter of a pencil. In determining the resistance of the carbon rods, the tips of latter were copper-plated when necessary and mercurial contacts used. The lamp was adjusted to burn at 50 volts potential difference for each set of pencils.

While every precaution was taken to avoid discrepancies, it is clear that from the nature of the substance experimented upon, and the extreme difficulty of maintaining constant conditions, errors are apt to creep into the work. But the results given in Table 3, as well as later determinations, undoubtedly point to the existence of such a law as has been quoted.

The relation between diameter and life having been investigated, experiments were then made to determine the curve for current and mortality of the pencil when the voltage is kept constant.

For this purpose a number of molded high tension carbons of the brand E were used. To secure uniformity in the plus and minus pencils, a 12-inch stick was broken in half, one portion being used as the upper, the other as the lower carbon. The length of each run was an hour. Current and potential were read every two minutes and the mean taken.

TABLE 4.
LIFE WITH DIFFERENT CURRENTS AND CONSTANT POTENTIAL.

CARBON.	Diam., mean, inches.	Resis., ohms.	Initial wt. + grms.	Initial wt. − grms.	C. amp.	P. D. volts.	Loss wt. + grms.	Loss wt. − grms.	Life per inch carbon burned, hours.	$\left\{\frac{\text{Life} -}{\text{Life} +}\right\}$
E molded high ten..	.518	.199	30.20	21.15	6.02	49.3	4.48	2.77	.6723	1.62
" "	"	"	25.72	18.38	7.04	49.7	4.87	3.19	.6047	1.54
" "	"	"	20.85	15.19	8.01	49.9	5.42	3.25	.5622	1.66
" "	"	"	37.56	24.16	8.99	49.9	5.81	3.63	.5450	1.60
" "	"	"	31.75	20.53	10.01	49.3	6.16	3.98	.5072	1.52
" "	"	"	30.52	21.72	11.00	50.2	6.67	4.18	.4910	1.60
" "	"	"	34.30	26.90	12.03	50.3	6.65	4.35	.4637	1.52
" "	"	"	37.78	26.33	13 00	50.1	7.26	4.61	.4562	1.57

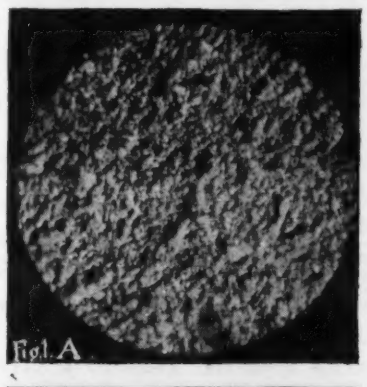


Fig. 1. A.

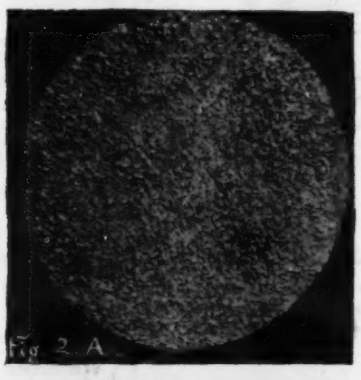


Fig. 2. A.

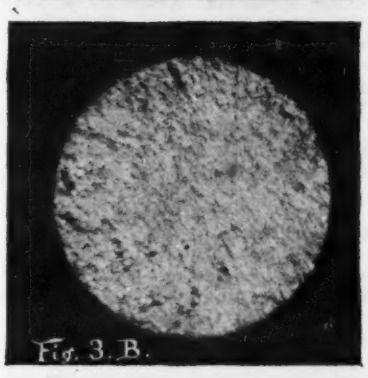


Fig. 3. B.

Fig. 4. B.

Fig. 5. C.

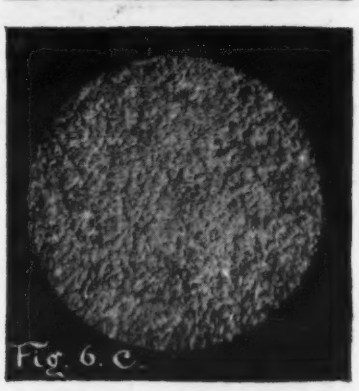


Fig. 6. C.

FIGS. 1 to 6.—SECTIONS OF CARBONS MAGNIFIED 40 DIAMETERS.

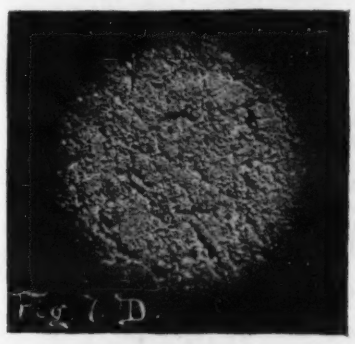


Fig. 7. D.

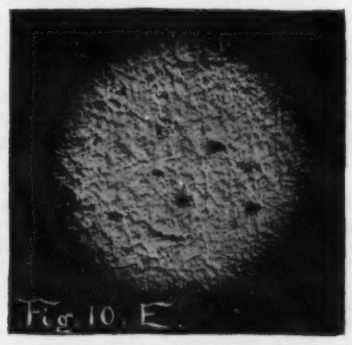


Fig. 10. E.

Fig. 8. D.

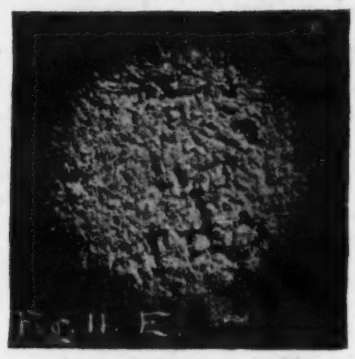


Fig. 11. E.

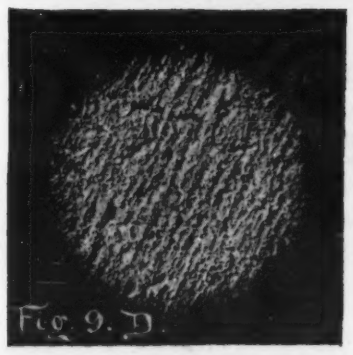


Fig. 9. D.

Fig. 12. E.

FIGS. 7 to 12.—SECTIONS OF CARBONS MAGNIFIED 80 DIAMETERS.

Table 4 gives the data from which the curve for current and mortality (Fig. 13) was plotted.

As will be seen, the range of current was from 6 to 13 ampères. The greatest variation of the mean E. M. F. for the several runs was one volt.

TABLE 5.
LIFE WITH DIFFERENT POTENTIALS AND CONSTANT CURRENT.

CARBON.	Mean diam., in. +	Mean diam., in. −	Resis. ohms.	Initial wt. + grms.	Initial wt. − grms.	C. ampères.	P. D. volts.	Loss wt. + grms.	Loss wt. − grms.	Life per inch carbon burned, hrs.	$\left\{\frac{\text{Life} -}{\text{Life} +}\right\}$
E molded high ten...	.513	.513	.199	51.58	48.52	10	40	5.625	2.32	.6425	2.344
"	.521	.517	.197	37.65	24.16	10	45	5.605	2.87	.6077	1.953
"	.531	.522	.185	24.86	19.06	10	50	5.83	3.49	.5453	1.693
"	.531	.522	.185	24.86	19.06	10	55	6.34	4.025	.4903	1.589
"	.527	.530	.191	23.52	19.34	10	60	6.70	4.41	.4525	1.484

A series of tests was now made with constant current and varying voltage. The current in this case was maintained at 10 ampères, and the range in tension was from 40 to 60 volts. Carbons of the same type as in the last instance were used. In table 5 are given the figures for these runs, and Fig. 14 shows the curve for voltage and mortality.

In the curves (Figs. 13 and 14) the ordinates represent the life of an inch of carbon in minutes. Reference is made not to the mortality of the plus pencil, but to the total amount of carbon burned in the lamp. The last two columns in Table 5 have been corrected for diameter and resistance of the pencil, the diameter and resistance respectively of the carbon that was burned at 10 ampères and 45 volts having been taken as a standard and the life of the other pencils reduced to a common basis from this, according to the law previously stated.

Very little has been published regarding the relative life of the plus and minus carbons. Those books in which the

* G. W. Parker. THE ELECTRICAL WORLD, March 3, 1888, p. 112.

subject is alluded to state, as a rule, that with direct currents the life of the upper carbon is about half that of the lower, provided both have the same length originally. In a recent publication* the general statement is made that "with continous currents the plus wastes twice as fast as the minus carbon. With alternating currents the upper wastes 8 per cent. faster than the lower if the carbons are vertical, but at the same rate if horizontal."

TABLE 6.

RELATIVE LIFE OF THE PLUS AND MINUS CARBONS.

Carbon.	Initial wt. + grms.	Initial wt. − grms.	C ampère.	P. D. volts.	Length run, minutes.	Loss wt. + grms.	Loss wt. − grms.	Life 1″ − / Life 1″ +	Life 1″ + / Life 1″ −
Tension.									
B molded high..	48.38	25.22	10	50	60	5.28	4.40	1.20	
B molded low...	61.43	31.37	10	50	60	5.14	3.27	1.57	
A molded high..	90.57	38.68	10	50	60	5.98	3.20	1.87	
10 E forced low..	344.68	244.64	22½	28	150	193.18	74.42	2.59	
10 B molded.....	367.80	259.50	22½	28	150	166.60	51.50	3.23	
10 C molded.....	594.40	294 50	22½	28	145	151.00	41.00	3.68	

No experiments were made upon arc-light carbons fed by alternating currents, but an investigation of the relative loss of the plus and minus pencils with direct currents gave quite interesting results. Table 6 shows that the plus carbon may burn away about as fast as the minus, or may waste more than three and a half times as quickly.

Three sets of experiments were undertaken to determine the elements that affect this ratio.

First. Effect of changing the diameter and resistance of the pencils with constant current and potential.

Second. Influence of change of current with constant potential.

Third. Change of potential with constant current.

For determining the influence of diameter and resistance upon the relative life of the plus and minus carbons, a number of molded high-tension pencils of the brand A were used. The carbons were supposed to be taken from the same "batch," and were burned with a current of 10 ampères and a P. D. = 50 volts.

Examining Table 7, which gives the results of measurements, we note that $\left\{\frac{\text{life}-}{\text{life}+}\right\}$ appears to become greater with increase of diameter of the carbon. It is probable that the inequality in the diameter of the + and — pencils respectively, as well as the difference in the resistances of the two carbons of a set, explains to a large extent the cause of this increase in the ratio. For, assuming that, under the conditions maintained, the life of a carbon varies directly with its diameter and inversely with its resistance, the data (Table 7) indicate that if the diameters and resistances respectively of the + and — carbons were the same in each run, the ratio would be practically the same for all sizes of carbons. This is brought out in the last column of the table, which gives the corrected values of $\left\{\frac{\text{life}-}{\text{life}+}\right\}$.

Second. Reference to the last column of Table 4 will show that a change in the current, other conditions remaining the same, probably has no effect on the ratio $\left\{\frac{\text{life}-}{\text{life}+}\right\}$. For when a current of six ampères was used, the ratio was equal to 1.62; at seven ampères the ratio dropped to 1.54; it then alternately increased and decreased to 13 ampères. Hence it may be said that if all

TABLE 7.

INFLUENCE OF DIAMETER AND RESISTANCE OF THE CARBON UPON THE RELATIVE LIFE OF THE + AND — PENCILS.

Carbon.	Mean diam inches. +	Mean diam inches. −	Resis, ohms. +	Resis, ohms. −	Initial wt. +	Initial wt. −	Loss wt. +	Loss wt. −	Life 1″ − / Life 1″ +	Life 1″ + / Life 1″ − corrected.
A molded high ten	.3964	.4083	.255	.243	37.91	16.97	4.96	3.04	1.64	1.79
"	.4567	.4567	.225	.213	48.98	20.26	5.41	3.28	1.65	1.78
"	.5018	.5153	.190	.207	59.87	25.10	5.86	3.59	1.63	1.74
"	.5698	.5622	.178	.190	69.83	26.91	6.23	3.61	1.73	1.81
"	.6311	.6368	.152	.149	90.57	38.68	5.98	3.20	1.87	1.83

errors or observation, as well as those due to irregularities in the carbons, could be eliminated, the $\frac{\text{life} - \text{carbon}}{\text{life} + \text{carbon}}$ would be found to be constant.

Third. The last column of Table 5 contains the data for $\frac{\text{life}-}{\text{life}+}$ with different P. D.'s and constant current. From these calculations it appears that the ratio depends on the P. D., and that the greater the P. D. the more nearly does the former approach unity. The curve plotted from the figures in Table 5 is given in Fig. 15, the abscissæ being volts and the ordinates representing the ratio of the life of the minus to the life of the plus carbon.

Thus the causes that influence the relative life of pencils of the same diameter lie chiefly in the difference in the resistance of the carbons and the variations of the P. D.

Judging from existing theories of the arc, it was thought that blowing the latter with a magnet during the runs would relatively increase the life of the plus carbon. The experiment was tried and the reverse was found to take place, *i. e.*, the ratio $\left\{\frac{\text{life}-}{\text{life}+}\right\}$ increased while the life of the minus pencil was not much affected.

EFFICIENCIES.

Two methods of determining the efficiency of each set of pencils were employed. The first was the method used by Mr. Merritt in obtaining the efficiency of the incandescent lamp,† and subsequently by Mr. Nakano in his work on the efficiency of the arc lamp.* The second dealt with candle powers, and will be referred to in the discussion of candle-power measurements.

It may not be amiss to give here an outline of the first method employed. A Thomson lamp was mounted on a movable frame and the rays from the burning carbons allowed to fall on the face of a thermo-pile, the latter being in circuit with a sensitive Thomson galvanometer. The deflection of the galvanometer was taken as a measure of the energy of the total radiation which fell upon the face of the pile. A cell containing a solution of alum has then interposed between the light and the pile, and the reduced deflection of the galvanometer noted. On the supposition that the alum cell cut off all the "dark heat" and allowed only the rays of the visible spectrum to reach the face of the thermo-pile, the last measurement would give the true value of the luminous energy emitted by the lamp. But a small per-

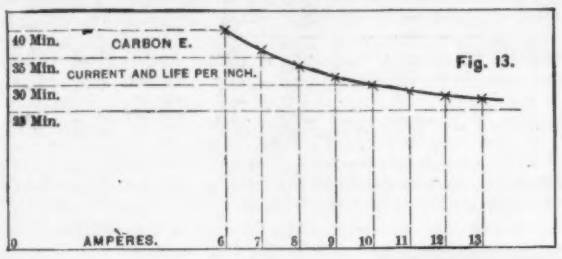


Fig. 13.

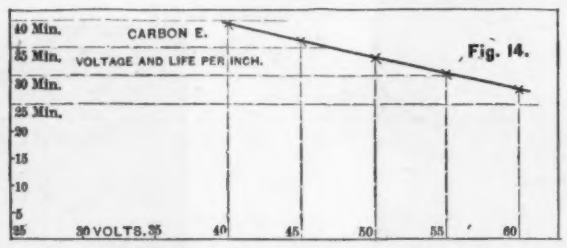


Fig. 14.

centage of the longer wave lengths passes through the alum cell, and no large part of the luminous rays is cut off by its intervention. Corrections having been made for these factors, the true values of luminous radiation resulted.

A mechanism was provided by which measurements could be made at various angles below the horizontal plane without altering the distance between the centre of the arc and the thermo-pile.

For the high-tension runs, the lamp was fed by a current of 9 ampères, the potential difference between its terminals being kept at 45 volts. For low-tension tests, current = 21½ ampères, and P. D. = 30 volts. Note that the amount of energy expended in the low-tension lamp was 21½ × 30 = 645 watts, while the high-tension required but 9 × 45 = 405 watts. Although normally the former requires from 520 to 560 watts, unsteadiness of the light when the lamp was run below 21½ ampères made accurate measurements impossible.

EFFICIENCY MEASUREMENTS.

TABLE 8.

Carbon A. Molded High Tension.

Angle	L	T	L/T
0°	6.085	110	.0553
10°	8.112	130	.0624
20°	11.49	134	.0858
30°	16.90	146	.1158
40°	23.67	146	.1621
50°	15.55	143	.1087
60°	10.14	125	.0811

TABLE 9.

Carbon D. Forced High Tension.

Angle.	L	T	L/T
0°	4.733	107	.0442
10°	8.133	118	.0688
20°	11.49	129	.0891
30°	14.20	142	.0977
40°	16.91	152	.1112
50°	19.61	156	.1257
60°	8.790	142	.0619

TABLE 10.

Carbon B. Unplated Molded High Tension.

Angle.	L	T	L/T
0°	10.14	114	.0889
10°	13.52	127	.1065
20°	15.55	144	.1080
30°	18.26	157	.1163
40°	22.31	165	.1352
50°	22.31	163	.1352
60°	15.55	156	.0995

TABLE 11.

Carbon B. Plated Molded High Tension.

Angle.	L	T	L/T
0°	11.49	116	.0991
10°	14.21	128	.1057
20°	15.55	145	.1072
30°	19.60	157	.1248
40°	22.31	164	.1361
50°	18.93	164	.1369
60°	15.55	141	.1103

TABLE 12.

Carbon E. Molded High Tension.

Angle.	L	T	L/T
0°	2 702	116	.0233
10°	5.405	134	.0403
20°	8 108	146	.0555
30°	13.51	157	.0861
40°	17 57	159	.1105
50°	11.48	145	.0792
60°	7.77	112	.0710

TABLE 13.

Carbon E. Forced High Tension.

Angle.	L	T	L/T
0°	2.702	118.5	.0228
10°	4.054	131.0	.0310
20°	6.756	158.	.0428
30°	6.081	——	.0483
40°	10.13	175.0	.0579
50°	14.19	155.0	.0895
60°	11.48	136.0	.0844

TABLE 14.

Carbon A. Forced Low Tension.

Angle.	L	T	L/T
0°	8.784	162	.0542
10°	12.16	170	.0715
20°	20.27	185	.1095
30°	25.68	190	.1351
40°	25.68	190	.1351
50°	16.89	157	.1080
60°	9.459	130	.0728

TABLE 15.

Carbon B. Molded Low Tension.

Angle.	L	T	L/T
0°	10.81	190	.0569
10°	17.57	211	.0833
20°	25.68	223	.1151
30°	28.38	223	.1273
40°	17.57	215	.0817
50°	12.33	182	.0678
60°	6.081	135	.0451

Tables 8 to 15 give the results of efficiency tests. In the columns headed (L) are given the corrected values of deflections due to luminous radiation; the values of (T) refer to total radiation and the efficiency or luminous divided by total radiation — $\left\{\frac{L}{T}\right\}$

These tables furnish the data from which the curves (Figs. 16 to 23) were plotted. The radii show the positions for which measurements were taken; and distances measured along these lines from the origin to the *dotted* curves, give the intensity of luminous and total radiation respectively in each position.

It will be seen that the distribution of total radiation differs considerably from that of luminous radiation, hence the efficiency, which is expressed by $\left\{\frac{\text{luminous radiation}}{\text{total radiation}}\right\}$ depends upon the angle of measurement.

The full line curves (Figs. 16 to 23) represent the efficiencies of the various carbons. In order to obtain the mean or hemispherical efficiency, the areas of the curves of luminous and of total radiation were found by means of the planimeter; now the ratio of the radii of two semi-circles whose areas are respectively equal to those of the curves of luminous and total radiation is the value of the mean spherical efficiency. This value has been calculated for each set of pencils, and the results are given in Table 16; also in Figs. 16 to 23.

TABLE 16.

EFFICIENCY MEASUREMENTS.

Carbon.	Diam. mean inches.	Resis. ohms.	C. amp.	P. D. volts.	Horizontal efficiency.	Maximum efficiency.	Hemispherical efficiency.	Life 12 inch + carbon hours.	C.	P. D.
A molded high ten..	.508	.203	9	45	.0553	.1621	.1171	10.22	10	50
D forced high ten	.457	.187	9	45	.0442	.1257	.1001	8.64	10	50
B molded (unplated) high ten....	.453	.224	9	45	.0889	.1352	.1269	9.16	10	50
B molded (plated) high ten.....	.453	.0805	9	45	.0991	1369	.1272	10.64	10	50
E molded high ten..	.533	.202	9	45	.0233	.1105	.0896	10.39	10	50
E forced high ten	.522	.251	9	45	.0228	.0895	.0776	10.09	10	50
A forced low ten....	.500	.072	21.5	30	.0542	.1351	.1105	10.55	21½	30
B molded low ten....	.498	.071	21.5	30	.0569	.1273	.0932	9.42	22½	28

We notice that the horizontal efficiency is very small compared with the maximum; that relatively high efficiency in a *forced high tension* carbon is obtained only at the expense of life; that a *molded* carbon is, generally speaking, superior to a *forced* for high tension and vice versa for low tension.

In the case of the high tension carbons B and D, the diameters are smaller than those of the other pencils, hence we are to expect a relatively higher efficiency; since, as was shown last year, the "efficiency varies inversely as the diameter."*

A point of interest brought out by these tests (Tables 10 and 11 and Figs. 18 and 19), is the fact that while the life of a copper plated carbon is greater than that of an unplated carbon of the same diameter and type, the mean spherical efficiency appears to be the same for both.

Two sets of pencils of the brand B, the one unplated and the other plated, were burned to ascertain this relation. The results show that the horizontal and the maximum efficiency of the copper-plated carbons were a little greater than those of the uncoated pencils respectively, and the mean spherical efficiency in the latter case was

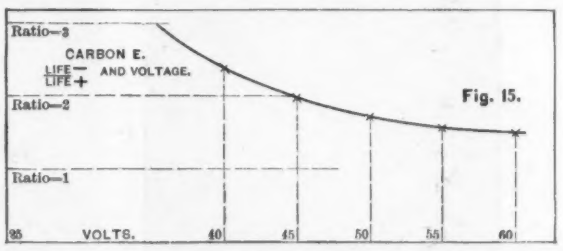


Fig. 15.

very slightly less than in the former. As can be seen from Table 16, the life of the "positive" plated pencil (12″ long) was 10.64 hours, while that of the naked carbon was 9.16 hours, the current and P. D. having been the same for both cases.

No positive explanation of this phenomenon has yet been given, but it appears that the actual amount of *combustion* in both cases is the same, while the *disintegration* caused by the passage of the current is greater in the case of the unplated carbon.

CANDLE POWER MEASUREMENTS.

The candle power measurements consisted chiefly in the determination of the hemi-spherical candle power of the different pencils, and, from this quantity, the watts per spherical candle power produced.

The runs were made under the same conditions as in the efficiency tests. For high tension carbons current = 9 ampères and P. D. = 45 volts. For low-tension pencils, current = 21.5 ampères and P. D. = 30 volts.

To ascertain the candle powers, the method of the Franklin Institute Committee was used. † The photometric apparatus was somewhat different in detail from that ordinarily used in measuring the candle power of incandescent lamps and deserves a brief description.

The arc lamp was suspended from an arm which could be rotated about an axis parallel to the photometer bar and vertically above it. By manipulating a rope connected with the arm, the latter could be raised until it was at right angles with the photometer bar, or lowered until it was horizontal. The arm being horizontal, the lamp was hung from its extremity so that the arc was on a level with the centre of the photometer-disc. It will be seen that when the arm was pulled up the arc described a vertical circle, the axis of which was a line parallel to the photometer-bar and passing through the centre of the disc. The centre of the vertical circle was at the point (800) of a scale graduated into (1,000) divisions, and the radius equal to the length of (200) scale divisions.

At the zero of the scale was placed a Weston incandescent lamp; and a circular mirror of silvered glass, the axis of which was horizontal and inclined 45 degrees to the reflecting surface, was mounted on the bar so that its centre coincided exactly with the 800th division of the scale.

* Munro & Jamieson's Electric Rules and Tables, 1889.

† E. G. Merritt: Some Determinations of the Energy of the Ligh from Incandescent Lamps. Amer. Jour. Science, Vol. XXXVII, p. 167.

* H. Nakano: Efficiency of the Arc Lamp. Paper read before Amer. Inst. Elec. Eng. *The Electrical World*, June 1, 1889, p. 313.

* H. Nakano. *The Electrical World*, June 1, 1889.

† Reports, International Electrical Exhibition of Franklin Inst., 1884, Group B, Sections V, and VIII.

Thus the distance between the arc lamp and the mirror was rendered constant for all elevations of the former, and when the mirror reflected the light of the lamp upon the disc, the angles of incidence and reflection were always equal to 45 degrees. The virtual image of the arc under these circumstances was at the 1,000th division of the scale. The Weston lamp was used as a secondary standard and maintained by a storage battery throughout the runs at 115 volts; its candle power was ascertained before and after the tests by comparing it with a standard Methven "Board of Trade" 2 c. p. slit.

Photometer readings were made, as in the case of the efficiency tests, at 0 and at 10, 20, 30, 40, 50 and 60 degrees below the horizontal, the mean of twenty observations being taken for each elevation. These measurements were multiplied by the candle power of the secondary standard and corrected for absorption of light by the mirror.

Tables 17 to 23 give the corrected data, which form the basis of the candle power curves (Figs. 24 and 25). Distances measured along the radii from the origin to each curve give the candle power for the various angles. The mean spherical candle power for any case is measured by the radius of a semi-circle whose arc is equal to the area of the c. p. curve.

Although great care was taken in ascertaining the candle powers, the difference in color between the light emitted by the arc and that given by the standard was so marked that the setting of the photometer carriage was to a large extent a matter of personal judgment; hence the measurements given cannot be considered as absolute, but rather as relative values.

The conclusions drawn from the efficiency curves hold generally, as will be seen by an examination of Table 24, for the candle power curves. From the latter it appears that the efficiency of low-tension carbons, and especially of *molded* low tension pencils, is comparatively small. While the efficiencies of molded high-tension carbons are as high as .953 and .888 watts per spherical candle or 783 and 840 candles per electrical horse power expended in the lamp, the efficiencies of low-tension pencils of nearly the same diameter as the high are as small as 1.255 and 1.612 watts per candle or 594 and 502 candles per electrical horse power.

TABLE 24.

CANDLE POWER MEASUREMENTS.

CARBON.	Diam. (mean), inches.	Resis., ohms.	C. amp.	P. D. volts.	Horizontal candle-power.	Maximum c.p.	Hemi-spherical c. p.	Watts per spher. c. p.	Spher. c. p. per elec. horse power.
A molded high ten	.568	.203	9	45	221	1053	456	.888	840
D forced high ten	.457	.187	9	45	210	1140	486	.833	895
B unplated molded high ten	.453	.224	9	45	382	1131	525	.771	935
E molded high ten	.533	.202	9	45	227	1080	425	.953	783
E forced high ten	.522	.251	9	45	222	626	288	1.407	531
A forced low ten	.500	.072	21.5	30	594	1183	514	1.255	594
B molded low ten	.498	.071	21.5	30	475	871	400	1.612	502

Carbon B (molded high ten., Table 24), it will be noted, has the highest efficiency of the group. This is due largely to the fact that its diameter is smaller than that of any of the others, for "the candle power varies inversely as the diameter."*

Similarly the relatively high candle power of carbon D is accounted for by the small diameter of the pencil. In Table 24 and the candle-power curves we again note the comparatively small efficiency of *forced* high-tension carbons.

The efficiency of carbon A (molded high tension, Table 16), as measured by $\left\{\frac{\text{luminous radiation}}{\text{total radiation}}\right\}$ is larger than that of carbon D; yet the mean spherical candle power of the latter is greater than that of the former (Table 24). The explanation of this phenomenon (assuming the measurements to be correct) probably lies in the difference in the *quality* of the light emitted.†

In some instances it is desirable to ascertain the mean spherical candle power of a lamp approximately, without taking the time to integrate the curve.

The formula given by M. Gérard, namely, "spherical c. p. = ½ horizontal c. p. + ½ maximum c. p."‡ is of sufficient exactitude for practical purposes. Gérard gives the following table showing the observed and calculated spherical candle powers for seven lamps:

TABLE 25.

GERARD'S MEASUREMENTS OF CANDLE POWER.

Lamps.	Horizontal c. p.	Maximum c. p.	Spherical c. p. calculated.	Spherical c. p. observed.
No. 1	250	1464	491	470
" 2	456	3250	1040	1145
" 3	560	3071	1048	1221
" 4	744	1227	679	692
" 5	122	840	271	274
" 6	586	2100	818	802
" 7	935	1150	755	767

Taking the whole number of lamps, the average error is only 5 per cent. "The angle of maximum intensity was about 45 degrees usually, but in some cases it approached that of 30 degrees or 60 degrees from the horizontal."

Data collected from various sources, including the tests of the Franklin Institute Committee in 1884, are given in Table 26. From the horizontal and maximum candle powers the mean spherical was calculated by Gérard's law. Comparison with the observed candle powers shows that in some cases the error is less than 1 per cent. The mean error is, however, larger than that obtained by Gérard, and reaches about 9¾ per cent. Hence, as was stated before, the law is valueless except in cases of rough approximation.

Reference has been made to the fact that while the curve for luminous radiation is similar to that of candle-power, the curve for total radiation differs widely from the latter. As the efficiency depends upon the ratio $\left\{\frac{\text{luminous radiation}}{\text{total radiation}}\right\}$ it is plain that Gerard's law will not hold for calculating the mean spherical efficiency from the horizontal and the maximum. But again, for approximations a similar law holds, *i. e.*,

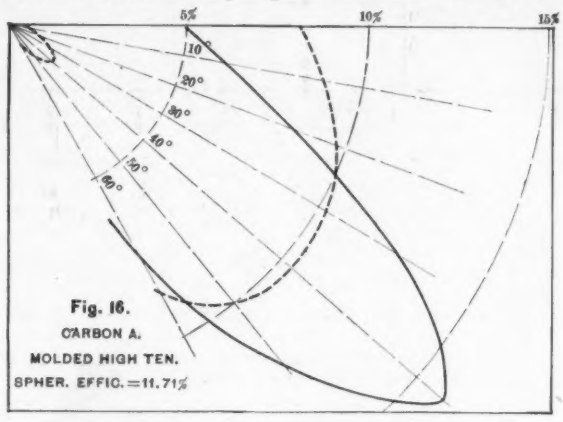
Spherical efficiency = ¼ horizontal + ¾ maximum.

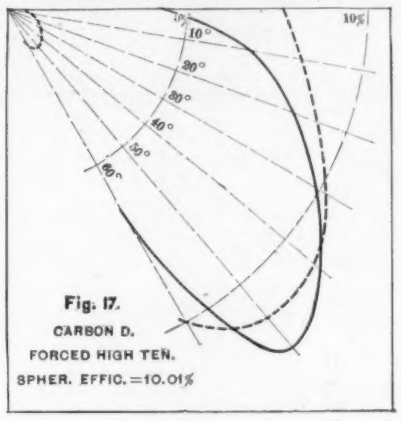
Although the topic of efficiencies has been discussed in another part of the article, it may not be out of place to add a few words here, bearing upon the law in question. Measurements of horizontal, maximum and mean spherical efficiency, made by Mr. H. Nakano and by the writer, are given in Table 27, and the last law mentioned applied in the calculation of the spherical efficiency. In some cases the error is exceedingly small, while in others it is comparatively large; the mean error of fourteen tests is not quite 8 per cent.

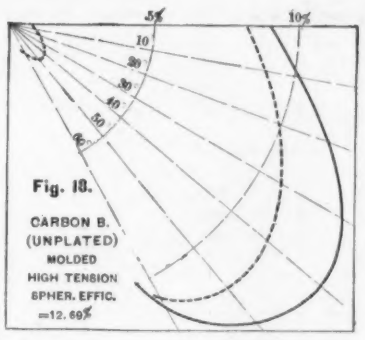
TABLE 26.

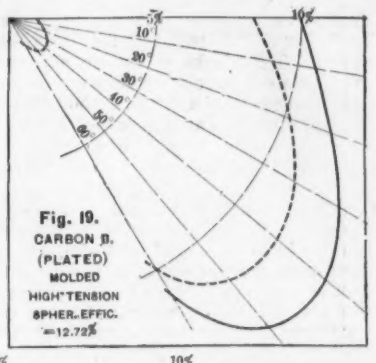
CANDLE-POWER CALCULATIONS, USING GERARD'S LAW.

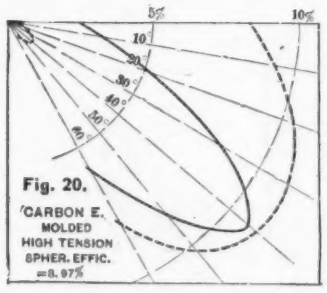
LAMPS.	Horizon. c. p.	Max. c. p.	Spherical c. p. observed.	Spherical c. p. Calculated.	Authority.
Weston	344	609	348	324	B. W. Snow.
"	299	576	295	293	"
"	576	1235	640	597	"
Brush	313	1395	609	504	"
Ball	233	534	240	249	Prof. W. A. Anthony
Brush (1200 c. p.)	180	617	263	244	"
Brush (2,000 c. p.	389	1380	653	539	"
Van Depoele (20-light)	451	1377	574	569	"
Van Depoele (60-light)	333	1155	470	455	"
Western Elec	263	355	186	220	"
Thomson-Houston	227	1080	425	383	L. B. Marks.
" "	222	626	288	267	"
" "	382	1131	525	474	"
Weston	594	1183	514	593	"
"	475	871	400	436	"

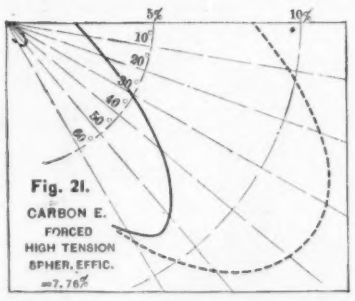


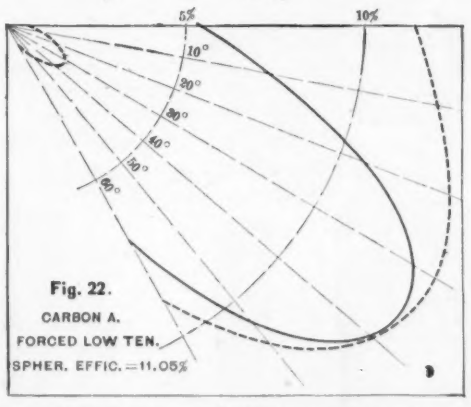


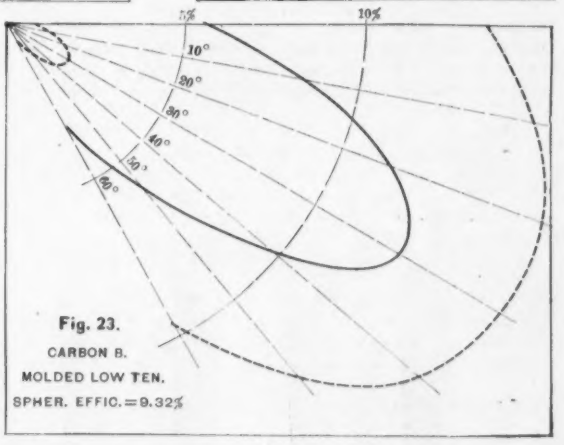












FIGS. 16 TO 23. DISTRIBUTION OF LIGHT FROM ARC LAMPS.

CANDLE POWER MEASUREMENTS.

TABLE 17. Carbon A; molded high tension.

Angle.	Candle power.
0°	221.3
10°	474.1
20°	713.1
30°	979 2
40°	1053.0
50°	928.6
60°	370.7

TABLE 18. Carbon B; molded high tension.

Angle.	Candle power.
0°	382 2
10°	638.4
20°	908.4
30°	1113.
40°	1131.
50°	749.3
60°	579.8

TABLE 19. Carbon D; molded high tension.

Angle.	Candle power.
0°	210.5
10°	407.4
20°	687.4
30°	977.1
40°	1079.0
50°	1140.
60°	595.7

TABLE 20. Carbon E; molded high tension.

Angle.	Candle power.
0°	227.3
10°	288.8
20°	429 9
30°	722.2
40°	957.2
50°	1080.
60°	414.

TABLE 21. Carbon E; forced high tension.

Angle.	Candle power.
0°	221.7
10°	238.
20°	350.1
30°	558.9
40°	626.3
50°	630.7
60°	265.5

TABLE 22. Carbon A; forced low tension.

Angle.	Candle power.
0°	593.7
10°	712.1
20°	866.3
30°	10?4.
40°	1183.
50°	682.2
60°	495.4

TABLE 23. Carbon B; molded low tension.

Angle.	Candle power.
0°	475.4
10°	593.7
20°	720.9
30°	871.3
40°	866.6
50°	528.4
60°	354.8

This fact is not brought out in Table 16, for reference to the latter shows the low-tension pencils to have a rather high efficiency, and in some cases considerably higher than the high-tension carbons. However, when the energy expended in the lamp in the two cases respectively is taken into account, the explanation of the high values for carbons A and B (Table 16, low tension) is apparent.

TABLE 27.

OBSERVED AND CALCULATED EFFICIENCIES.

CARBON.	Horizon. Effic.	Max. Effic.	Spherical Effic. observed.	Spherical Effic. calculated
.832 inch	1.82%	9.00%	6.87%	5.60%
.563 "	4.12%	14.41%	11.00%	11.83%
.500 "	4.91%	17.33%	12.06%	14.22%
.450 "	5.48%	15.52%	13.30%	13.01%
.370 "	5.55%	17.50%	15.54%	14.51%
.250 "	8.44%	19.80%	16.60%	16.96%
A molded high ten	5.53%	16.21%	11.71%	13.53%
D forced "	4.42%	12.57%	10.01%	10.53%
B (unplated) "	8.89%	13.52%	12.69%	12.37%
B (plated) "	9.91%	13.69%	12.72%	12.75%
E molded "	2.33%	11.05%	8.96%	8.87%
E forced "	2.28%	8.95%	7.76%	7.29%
A forced low ten	5.42%	13.51%	11.05%	12.68%
B molded "	5.69%	12.73%	9.32%	10.96%

OBSERVATIONS OF THE ARC AND THE CARBON-POINTS.

With a given potential difference between the terminals of the lamp, the length of the arc depends upon the current flowing, and increases as the current becomes greater. If the current be kept constant, the length of the arc increases with the P. D.

Data given in Tables 28 and 29 show the length of the arc for both cases.

TABLE 28.

LENGTH OF ARC: CONSTANT POTENTIAL.

CARBON.	Current amp.	P. D. volts.	Length of arc; inches.
E, molded high tension	6	50	.087
" "	7	"	.114
" "	8	"	.137
" "	9	"	.147
" "	10	"	.150
" "	11	"	.154
" "	12	"	.156
" "	13	"	.167

* M. Schreihage: Centralblatt für Elektrotechnik, No. 22, 1888.

† The reader is referred in this connection to "A Spectrophotometric Comparison of Artificial Sources of Illumination." Paper by Edward L. Nichols and W. S. Franklin, read before A. A. A. S. at Cleveland, Aug., 1888.

‡ M. Gérard: Candle Power of Arc Lamps—Centralblatt für Elektrotechnik; also N. Y. ELEC. WORLD, Jan. 25, 1890.

TABLE 29.

LENGTH OF ARC: CONSTANT POTENTIAL.

Carbon.	Current amp.	P. D. volts.	Length of arc; inches.
E, molded high tension.....	10	40	.073
" "	"	45	.095
" "	"	50	.141
" "	"	55	.186
" "	"	60	.216

In order to measure the length of the arc, a lens was so mounted as to throw the magnified image of the former upon a surface carrying a vertical scale. Then, after

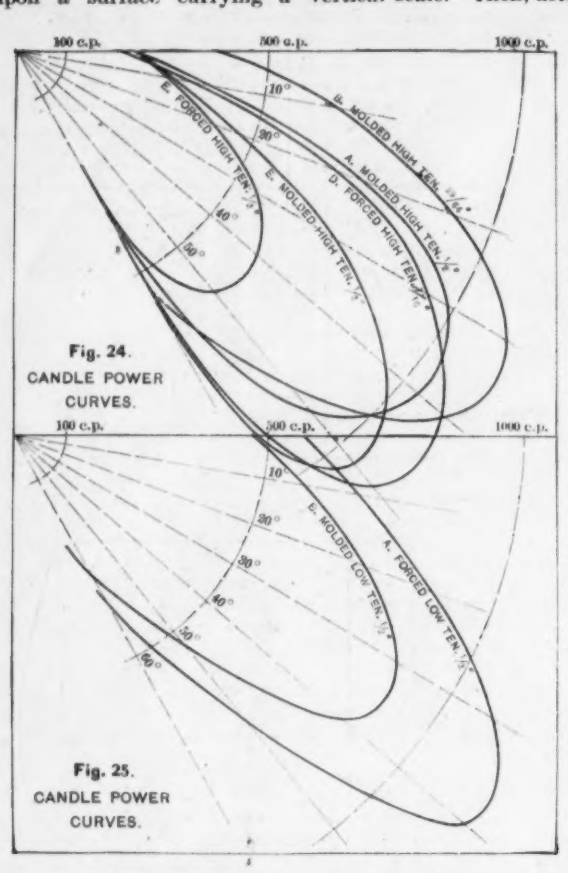


Fig. 24.
CANDLE POWER CURVES.

Fig. 25.
CANDLE POWER CURVES.

measuring the distance between the magnified points and applying the proper reduction factor, an additive correction was made for the depth of the crater, thus giving the length of arc from the tip of the minus pencil to the point directly above in the centre of the crater of the plus.

From the figures (Tables 28 and 29) it seems that no direct relation exists between the length of the arc and the current and P. D. In the case of the carbons tested, the length of the arc with constant potential increased very rapidly, as the current was changed from 6 to 9 ampères, and then gained slowly from 9 to 13 ampères. The nature of the change was somewhat different in the constant current runs, the length of the arc increasing more nearly as the square of the voltage.

After each of the runs noted in tables 28 and 29 the carbon points were examined, and it was found that the latter assumed particular shapes depending upon the current and P. D. used. Another series of tests was made with carbons C and E (molded high ten.) in which the current ranged from 5 to 15 ampères, the P. D. being kept constant at 50 volts.

Fig. 26 shows the form of the points with different currents. Nos. 1, 2 and 3 are pencils of the brand C, and 4, 5, 6 and 7 of the type E. The photographs of the carbons are three-quarters of the actual size.

Examining the first three pencils, we see that with 5 ampères there is a tendency to form a "mushroom" on the lower or negative carbon; the latter is eaten away considerably just below the tip. With 10 ampères this tendency is not at all marked and at 15 almost inappreciable.

Glancing at the upper or plus carbons, it appears that the smaller the current the more nearly does the positive pencil burn to a point, that is, the smaller the diameter of the crater. But though the width of the crater is less in the case of low currents than with high, the depth of the former is correspondingly greater. The photographs do not bring out this point, but an inspection of the tip of the lower carbon gives a clue to the facts. Note that with small currents the negative electrode terminates in a pointed, sometimes globular projection. As has been stated before, this tip becomes less noticeable with increase of current, a fact which is brought out by inspecting Nos. 7, 6, 5 and 4 (Fig. 26). In No. 4, burned at 15 ampères, the end of the lower carbon is blunted; the depth of the crater in the upper was practically zero. In Nos. 5, 6 and 7, burned at 12, 9 and 6 ampères respectively, the depth of the crater increases as the current diminishes.

With high currents the carbon is disintegrated to a greater distance above the point than with low.

Fig. 27 shows the form of the carbon points when the latter are burned with constant current = 10 ampères. The range in P. D. was from 40 to 60 volts.

Just as the peculiar burning of the tip distinguishes a pencil fed by a low from one burned at a high current, so the form of the carbon point differs in the case of a pencil burned with low voltage than with high. In Nos. 1, 2, 3, 4 and 5, Fig. 27, the gradual change in the formation from a sharp projection at 40 volts to a blunt end at 60 volts is noticeable.

The "mushroom" which invariably forms in carbons burned at a low current and high voltage is absent when the pencils are burned at high current and low voltage.* In the former instance the thin neck of the "mushroom" often breaks, thus arresting the current and extinguishing the arc. In the latter case the end of the carbon is prone so to burn away as to leave a concave outline. (See No. 1, Fig. 27.)

At 40 volts the depth of the crater measured .051 inch. At 60 volts the crater disappeared; the carbons also "flamed" at this high voltage.

With a given current there is for every brand of carbon a certain voltage, above which, if the pencil be burned, "flaming" will result. A simple trial is sufficient to determine this critical point.† Again there is a voltage, below which, if the carbon be burned, "hissing" takes place. With perfectly centered carbons there is no difficulty in ascertaining the latter point.

Careful observation of the arc shows that when the tension is too high for a given carbon, the walls of the crater break away, allowing the arc to play on the outside surface of the carbon. This action is always accompanied by a flame, which shoots from the negative carbon. On placing the negative pencil above and the positive below, the flame shoots down. With soft-cored carbons, well centered, one cause of flaming—namely, liability of the arc to play laterally—is obviated; and if the pencils be burned with the proper current and voltage, there seems to be no reason why this disagreeable feature of the arc lamp should not be entirely overcome.

There is not so much liability to "hiss" in a high tension system as in a low, for from the formation of the carbon-points when the pencils are burned in commercial low tension lamps, it appears that the minus carbon terminates in a small mushroom-button. The breaking of this pellicle of carbon and the consequent action of the lamp-mechanism to reduce the rise in potential due to the rupture invariably result in the "hissing" of the arc.

Most of the irregularities in the action of arc lamps probably result more from the unsuitableness of the carbon than from defects in the lamp mechanism or changes in the strength of the current and P. D. in the line.

The remedy lies with the carbon manufacturer. A careful study of the relation between the microscopical structure of the pencil and the action of the latter in a given case would be likely to bear fruitful results. Of course the field for experimentation is large, but the improvements which must necessarily follow conscientious research will undoubtedly be of great scientific as well as commercial value.

In the present state of the art of carbon manufacture, it is the central station manager who must exercise great discrimination in the selection of arc-light pencils for his plant. Mr. E. F. Peck has recently shown how a "comparative test of the best carbons in the market" resulted in "a saving of 64.73 electrical horse-power in a station burning a thousand arc arc lamps."‡

But there is no reason why the carbon manufacturer, given the condition of a lighting system as regards current, tension, required light and life of pencils, etc.—should not be able to produce a carbon specially adapted to the needs of that system.

When the root of existing defects is thus struck at, the solution of the arc-light carbon problem will be at hand.

The experiments published in this paper were made under the direction of Professor Edward L. Nichols, in the laboratory of Cornell University. The writer is indebted to Mr. A. B. Levy, R. G., for valuable assistance in the work.

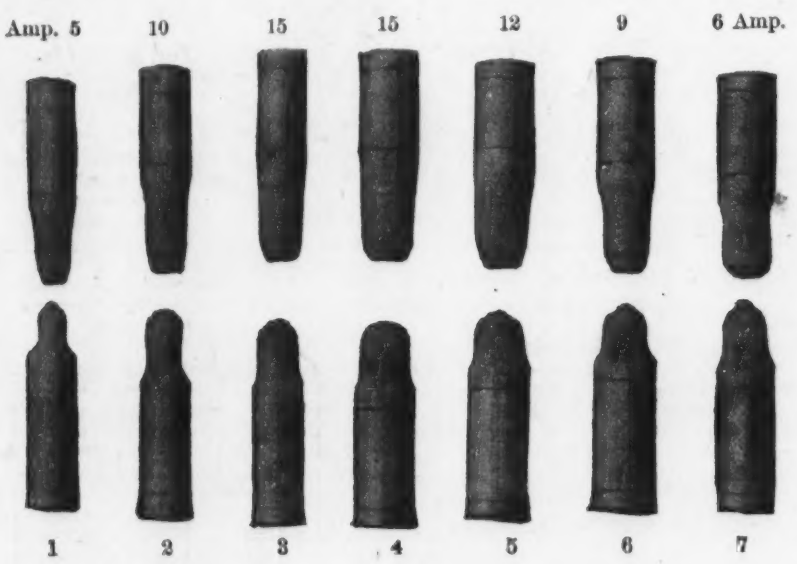


Fig. 26.
Form of the Carbon Points: Constant Potential—50 volts.

Fig. 27.
Form of the Carbon Points: Constant Current—10 Amperes.

* When the carbon is impure and contains a large amount of silica, the latter is often deposited in the form of a glass bead on the point of the negative pencil. The "mushroom" alluded to in the text does not refer to this deposition.

† O. G. Pritchard: Electric Arc Light Carbons. London *Electrician*, March 21 and April 4, 1890.

‡ E. F. Peck, of Brooklyn, N. Y.: Carbon Tests.—The Electrical World, Feb. 22, 1890.

Note on a New Photometer.*

BY PROF. EDWARD L. NICHOLS.

Methods of photometry which take no cognizance of differences of quality are so ill adapted to the study of sources of light which differ from each other widely in temperature, that the introduction of some instrument, by means of which both the character and intensity of an illuminant can readily be determined, would be a desirable adjunct to the equipment of our photometer rooms.

The instrument which it is my purpose to describe has been designed to meet this need. Existing types of the spectrophotometer may be made to give good results, but they are expensive instruments and so difficult to use that it is only in the hands of observers of considerable experience that accuracy is assured.

The new apparatus, the "horizontal slit" photometer, is, in point of fact, a spectrophotometer in which the polarizing device is entirely done away with. In it the extremely simple principle of the Bunsen photometer is applied successively to the various regions of the visible spectra of the source of light which are to be compared. A direct vision spectroscope of Browning's form is attached to the usual car of a Bunsen photometer, from which the disc and mirrors have been removed. The optical axis of the collimator is horizontal and at right angles to the photometer bar. The slit is horizontal and lies in a straight line joining the sources of light, which are set up in the usual manner at the ends of the bar. The bar itself is preferably of considerable length—in the case of the one upon which the original instrument under consideration

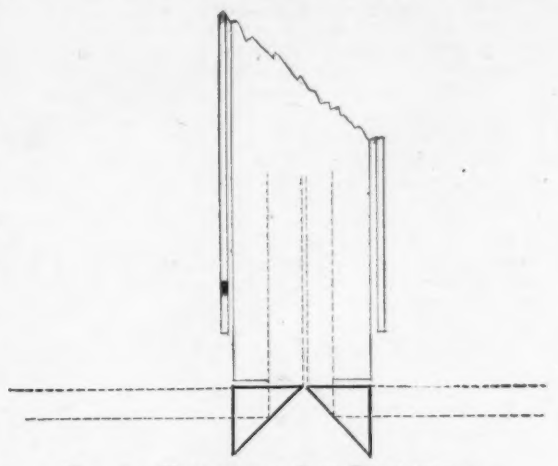


Fig. 1.—Horizontal Slit Photometer.

was mounted, it was 500 centimetres long, and should be divided into 1,000 equal parts.

In front of the spectroscope slit are placed two right angled prisms of the same size and made of the same glass (see Fig. 1). Their vertical adjacent edges bisect the slit, and light traveling from either end of the photometer bar is totally reflected by them and enters the right or left hand end of the slit in a direction parallel to the optical axis of the collimator tube.

The two sets of rays thus gathered into the spectroscope from the lights at the end of the bar are vertically dispersed by the Amici prisms and appear in the field of view as two vertical spectra standing side by side. Equal wave lengths are in the same horizontal line, and any desired region may be brought into the centre of the field by an angular movement of the ocular telescope. The telescope moves along the arc of a suitably divided semi-circle, to which it may be clamped by means of a set-screw. Wave lengths, corresponding to the various circle settings, are determined once for all, by observation of the more prominent of the Fraunhofer lines.

When the instrument, thus mounted, is placed at the middle of the photometer bar, between lamps which are identical in intensity and quality, the two spectra are of equal brightness throughout, wave length for wave length, from red to violet. If the two lamps differ in intensity but not in quality, the two spectra will differ in brightness by the same amount from end to end, and a position may be found upon the bar for which they will be identical throughout.

Under these circumstances, which are the only ones in which the Bunsen method in photometry is strictly applicable, the instrument may be used as a simple photometer, the setting for any wave length whatever giving the candle power. For this purpose alone, viz., for the comparison of lights of similar character, the instrument offers certain manifest advantages over the various forms

* A paper read before the General Meeting of the American Institute of Electrical Engineers, Boston, May 21, 1890.

of the Bunsen photometer. In the course of the present paper I shall present some definite data concerning the relative sensitiveness of the two instruments when used in this way.

When the lights to be compared differ, both in intensity and quality, ordinary photometric indications possess no perfectly definite significance. In this, which is the more general case, the relative brightness of the spectra of the two sources varies with the wave length. For each region of the visible spectrum, however, a position upon the photometer bar can be found at which the brightness of the two spectra in that region will be equal, and the observations thus obtained, when extended over the entire spectrum, will afford data by means of which the differences in quality of the two sources of light may be definitely expressed.

In a recent paper read before the Institute (*Transactions of the American Institute of Electrical Engineers*, Vol. VI., p. 183), for a considerable range of temperature at least, the ratio between the intensities of a certain wave-length of the spectrum of glowing carbon, is identical with the ratio of candle-powers as determined by the Bunsen photometer. The wave length in question, determined from the intensity of the spectrum of incandescent lamps at various candle-powers, I had found to be approximately $\lambda = 600$. M. A. Crova, in an important paper since presented at the late electrical congress at Paris,* has pointed out the importance of this method of measuring the light from sources differing in temperature. The wave length which he has indicated for this purpose is $\lambda = 582$, which belongs to a region lying slightly further toward the green than the one which I had adopted.

When the wave length of this region has been established beyond question, the photometry of lights which vary in color will have been reduced to a definite scientific basis. Instead of attempting to use the Bunsen photometer in measurements to which it is not adapted, we shall be able to deduce the relative candle power of two sources of light from the comparison of a single wave length, and we shall be freed from the uncertainty arising from differences of color and from the personal errors due to the independent use of the two eyes in observation. The determination of candle power will then be an operation of precision, even when the sources of light to be compared vary widely in temperature. It is in the opportunity of performing such observations upon the photometer bar itself, under conditions which do away with many of the sources of error inherent in the usual methods of spectrophotometry, that the chief advantage of the new photometer will be found to lie.

The following set of observations, taken with the new instrument, may serve to indicate one of the uses to which it may be put. The data are taken from an investigation now in progress in the physical laboratory of Cornell University. The object in view was to compare the spectrum of a novel type of gas burner with that of an ordinary argand burner. The two lamps were set up at the ends of a photometer bar five meters long, the bar, as already stated, being divided into 1,000 equal parts. Readings were taken at six points in the spectrum. The purposes being to express the relative brightness of the two spectra, wave length for wave length, the intensity of that due to the argand burner was taken as unity throughout, and the brightness of each region of the spectrum of the flame under investigation was obtained in terms of that of the corresponding region of the spectrum of the argand. The results are given in Table 1.

TABLE 1.

Comparison of a spectrum of a Welsbach burner with that of an ordinary argand burner, by means of the "horizontal-slit photometer."

Color.	Wave length.	Light-ratio, (Welsbach Argand).	Probable error of a single observation.
			Per cent.
Red	702	0.709 ± .017	2.45
Yellow	589	1.476 ± .017	1.14
	558	1.760 ± .025	1.34
Green			
	500	2.395 ± .047	1.99
Blue	466	2.738 ± .036	1.30
Violet	439	3.090 ± .073	2.35
Average			1.76

Ten observations were made in each region.
From observations by Miss Ida M. Hill.

I introduce these measurements here simply as an illustration of one line of work to which the instrument under consideration is adapted. A full description of the research of which they form a part, and which covers many other questions pertaining to the very interesting class of lamps with which it deals, will doubtless be published in due time.

As will be seen from the column of probable errors, the sensitiveness of the instrument is greatest in the region of the D line ($\lambda > 589$), and least in the extreme red and violet, where the light intensities are small.

A set of ten determinations made by the same observer with the Bunsen photometer, gave for the total light ratio of the two lamps,

$$\frac{\text{Welsbach}}{\text{Argand}} = 1.701 \pm .015.$$

The probable error of a single observation in this series amounted to 0.89 per cent., a value somewhat smaller than that obtained with the new photometer in the yellow of the spectrum.

The number of observations is too small to afford a close estimate of the relative sensitiveness of the two instruments, but the results suffice to show that the "horizontal-slit" photometer does not differ appreciably in accuracy from the Bunsen photometer when the latter is used in the comparison of flames of the same color.

When it comes to the measurement of sources of light that differ widely in temperature, the comparison is decidedly in favor of the "horizontal-slit photometer," the sensitiveness of which is not affected by differences of color. The error of the Bunsen photometer in candle-power measurement of the arc light, for instance, calculated from ten observations recently made upon the same photometer bar, the reference standard being an argand gas burner, was 2.65 per cent. (probable error of a single observation), a value more than twice as large as that of the "horizontal-slit" photometer.

A comparison of the performance of the new photometer with that of a polarizing spectrophotometer of the type which is commonly recognized as affording the highest degree of accuracy, is likewise decidedly in favor of the former. Taking as a basis eight observations made by Mr. Franklin and myself in the study of a bat's-wing gas burner,* the observations covering eight regions of the spectrum, I find the error of a single observation in the various regions, to have been as follows:

TABLE II.

Probable errors of a single observation with a polarizing spectrophotometer, calculated from sets of 10 observations upon various portions of the spectrum of a gas flame.

Wave-lengths.	Probable error of a single observation.
753	7.9 per cent.
668	4.9 "
608	4.5 "
557	5.4 "
518	6.4 "
492	7.0 "
468	3.0 "
450	2.4 "
Average	5.2 "

The measurement of a fluctuating illuminant, such as the gas-flame, is a line of investigation by no means adapted to exhibit any photometric instrument at its best; but as the errors of the horizontal-slit photometer, already given, were calculated from sets of ten observations upon such flames, I have selected for comparison similar sets of ten upon sources of the same character.

The averages, viz.:

Error of horizontal-slit photometer, 1.76 per cent. (average for spectrum).

Error of polarizing spectrophotometer, 5.20 per cent. (average for spectrum);

doubtless afford a fair indication of the relative performance of the two instruments in this peculiarly trying line of work.

At the last annual meeting of the Institute, I had the privilege of presenting a brief study of certain personal errors pertaining to the use of the Bunsen photometer. The particular class of errors to which attention was called in that paper† are undoubtedly obviated by the use of the horizontal-slit photometer; what new ones the latter instrument may introduce remains to be determined.

* M. A. Crova. *La Lumière Electrique*, Vol. 33, p. 478; THE ELECTRICAL WORLD, Vol. XIV., p. 189.

* *American Journal of Science*, Vol. XXXVIII., p. 100. See also "Transactions of the American Institute of Electrical Engineers," Vol. VI., p. 177.

† Transactions of the American Institute of Electrical Engineers, Vol. VI., p. 335.

‡ A paper read before the General Meeting of the American Institute of Electrical Engineers, Boston, Mass., May 21, 1890.

Electric Lighting in the Tropics.‡

BY W. H. FLEMING.

One of the chief difficulties that an engineer experiences who is called upon to install a plant of any considerable size in tropical countries is the trouble of procuring any skilled labor for this particular class of work. Another difficulty is that he is so far from his base of operations—the factory—which will often lead him to depend upon himself in overcoming obstacles that arise from time to time as the work progresses. Language and the heat, as well as fevers, are minor affairs.

Electric lighting has already gained many warm adherents both in the East and West Indies, more especially in the former, where plants of considerable capacity have been in active operation for the past eight years. It is especially adapted for use in houses, in warm climates, such as that of India, where the old-fashioned "punkah" is in daily and nightly use for cooling the rooms, accompanied with its attendant noise, as the "punkah wallah," a servant, pulls it backward and forward, causing the continual flickering of the lamps or gas. That system will, in time, I hope, give place to the noiseless motor fans and steady incandescents, thus enabling the Anglo-Indian to read and rest in comfort.

A central station plant that the writer was engaged upon lately in one of the chief cities of the West Indies would compare favorably in size and equipment with one situated in a city of a corresponding number of inhabitants in the United States. Alternating current dynamos of a capacity of 4,500 16 candle power lamps were employed for lighting the chief stores, theatres and private houses, and 600 arc lights of 1,200 candle power each lighted up the main streets and parks.

It was at first intended to run a small plant in connection with the existing gas works, more as an experiment than with a view to actual financial success, but in the space of six months the station was more than trebled from its original capacity.

The people took to it from the start, paying cheerfully the prices that were demanded. To an indolent race it was a great boon. Money to them, it would appear, was of less account than the trouble and work called upon to go around and light up the different oil and gas lamps, since all the lights were switched on the different circuits at sunset. In the tropics, as is well known, there is no twilight. Darkness comes on within 10 minutes of sundown and the whole plant practically goes into operation at once.

The construction work on this particular plant was necessarily somewhat slow, as men unaccustomed to erect a 30 or 45-foot pole took their time to do so, in which operation they received the appreciation of the usual army of idlers. Poles suitable for carrying a number of circuits had to be imported from the United States, as well as the ornamental wooden columns for supporting the lamps in the parks and public squares. Poles of native growth could not be found straight enough, and even if of sufficient length were weak Some poles could have been had from a tree called the ironwood tree. This wood, however, is of so close a grain and so very heavy that it was out of the question to use it. Many of the business streets were not more than from 20 to 30 feet across, including the sidewalks. Moreover, as curtains or awnings are stretched overhead from side to side by the owners of the stores to shelter and protect their goods from the sun's rays, it was impossible to erect a pole line down these streets. I found it better to run a 2-inch iron piping up to the side of the houses every 150 feet to a point 6 feet above the coping stone and then attaching to the top of this pipe a T, inserting in this T wooden cross arms, to which the insulators were attached in the usual manner. It must be borne in mind that the houses are not of very great height. Where this arrangement was impracticable, owing to the varying heights of the houses, I inserted strong iron brackets in the buildings, set in with cement and well painted with rust-proof paint.

In India considerable care has to be exercised in putting up a pole line. If you want your work to stand any length of time, the base of the poles for one-sixth of their length must be thoroughly well creosoted to resist as far as possible the ravages of an insect called the white ant or "termite." These insects live on wood. They attack even the woodwork of the houses, and soon reduce the thickest timber to a mere shell. They live in trees and construct nests of great size, like small sugar casks, made of particles of gnawed wood and cemented by a kind of gluten. They are so strongly attached to the branches that they cannot be shaken down even by violent storms. It is a good plan to paint the poles eight feet above the surface of the ground with good gas tar if obtainable. In these climates special attention should be given to protecting the working parts of arc lamps, owing to the fact that rain occurs only for about three months of the year, and to make up for this loss, the humidity of the atmosphere is remarkable. It is not at all infrequent to find early in the morning the bottom carbon holders full of water unless provision is made for draining this off. During the hot season a breeze springs up between 9 and 10 o'clock in the morning, and the ground being dry, the dust is terrific. Insects of a large size—much more so than those found in the northern climates—bats and small birds attracted by the glare are found either in the globes or lying at the base of the lamp posts in large quantities every morning; and the wholesale slaughter that takes place nightly seems to have no effect in diminishing these pests.

It was found better, therefore, on the arc service to give a man about 25 lamps to trim and clean per day, and the native entrusted with this work was held responsible, and if the lamps were found in a dirty condition he was fined, which usually had a good effect.

In the construction of station buildings one is guided much by the facilities for procuring stone, brick, or other suitable material in that particular locality. Galvanized iron is sometimes used for roofing, but more frequently roofs are constructed of a sun-baked clay tile, provision being made as is usual for an ordinary wire tower for distributing the various circuits. A point to be noted is that the engineer should construct his rain gutters for taking off the storm water at least double the size that is ordinarily allowed for temperate climates. Roofs and the outsides of the buildings are white-washed.

To give an idea of the heat from the sun, I may mention that I had to replace considerable quantities of insulated wire after it had been up only a short time, the insulation in places sagging right away from the copper wire and finally dropping off.

During the rainy season prevailing in the West Indies in the months of June, July and August, and in the East Indies known by the name of the southwest monsoon, and prevailing from May to the latter part of August, electrical storms occur almost daily. They are often exceptional in violence, and much trouble and anxiety arises from possible damage to line, lamps and dynamos, even though protected by good lightning arresters.

While a heavy storm was in progress one night last summer in the West Indies, I noticed when in the station a curious effect of a flash that fused the lead strips on an ordinary saw-tooth arrester connected with one of the incandescent circuits. The strips were entirely destroyed or volatilized, and what was before a polished plate of brass was now tarnished with a film of the lead vapor, and there was distinctly marked as if photographed on the plate a ziz-zag streak, in all appearance like a photograph that had been taken of lightning. Engineers, during the prevailing season of storms, should take particular pains that their lines and machines are thoroughly well protected and that the arresters have good earth connections.

A sad case came under my notice that happened at a temporary installation for illuminating a camp in Poonah, in the Bombay Presidency, with arc lamps in honor of a visit of an influential rajah. While the festivities were taking place in the evening, a heavy storm occurred. Lightning entered on the line—no provision had been made for diverting its course—and it destroyed the dynamo besides killing the native oiler who just at that moment was engaged in filling up the oil cups on the bearings. He was either thrown or fell across the commutator end of the dynamo, as he was found in that position, his hands much burnt as well as his feet.

In the year 1877 the first commercial arc lamp was in use at the offices of the Bombay *Times*, and if I remember correctly it was the first light shown in the Indian Empire. From that date on the demand for lighting has been on the increase; but pretty nearly all the work has been confined to isolated work and small central stations, cotton mills, sugar and indigo plantations, government buildings and large private dwelling houses. Places of business and offices do not require lighting, as business is conducted by the merchants only from 7 o'clock in the morning till 4 in the afternoon. The inhabitants of hot climates necessarily spend much of their time out of doors and are fond of social gayety. They have been famous for centuries for skill in illuminating, and this fact has added much to the popularity of arc and incandescent lamps, which as is well-known particularly lend themselves to artistic illuminating purposes. From this knowledge, in the early part of 1885, I imagined that it would be a financial success to get together a traveling portable electric light plant, consisting of a vertical boiler, engine and two dynamos, one an 8-arc light machine and the other a 100-light incandescent, both mounted on a stout frame which rested on a pair of trucks. This work was carried out, and I was kept actively employed for many months in going round to different large Indian estates and native palaces for the fetes that attend the various religious and family ceremonies that the wealthy natives are fond of indulging in. Large sums of money are spent, and the festivities often last for a week or longer. It turned out to be as I surmised it would, a regular "bonanza," until on one occasion in bringing the unwieldy contrivance down a steep hill, on one side of which was a ravine, it fell over; and it is needless to relate that the whole apparatus was seriously damaged. I found it would not pay to patch it up again, so, after stripping everything that was portable, I left the remainder to lie and rust in the tropical vegetation.

Owing to the high price of coal, which is a costly article in the tropics, ranging from $8 to $50 per ton delivered, it is well to employ the most efficient and economical engine for motive power, more especially for central station work. In the station previously referred to we were running with high-speed compound condensing engines with satisfactory results.

In many sugar plantations in the West Indies where the installations are of a comparatively small size, economy in

this direction is not practiced, as the amount of steam used is not missed, the boiler capacity on estates ranging from 100 h. p. to one at Cienfuegos, Cuba, of 2,500 h. p. It behooves the engineer, however, who has charge of a plant to exercise considerable care and watchfulness over his native firemen. The natives, as a rule, I have found, if treated with kindness and forbearance, show an aptitude in learning and taking hold that is often remarkable, more so than with some of their brethren of a lighter color, who, because they have been taught how to start and stop a dynamo or trim an arc lamp, give themselves all the airs of an expert in electrical matters, and have got beyond that stage when they are willing to be instructed or to be obedient to orders---an unwillingness that sometimes leads to disastrous results.

The types of machines chiefly in use in the East Indies are those of English and French manufacturers, Siemens, Gramme, Silvertown and other well-known types. Those in use in the West Indies and South and Central America are generally of American make, and the market is not a small one. The great strides that both the foreign and home companies have made in the last two or three years in the supply and equipment of electrical plants for these distant lands, are very evident signs that this particular business is receiving great attention at the hands of local merchants, planters and city or town officials, and that they are more and more influenced by the many advantages to be gained by the use of electric lighting. Planters find now that it is much to their gain in a financial way. In former years, for example, the facilities of shipping their produce were restricted, and the work was done in daylight and slowly. Now with weekly and almost daily sailings, it is an absolute necessity that they should get their produce ready with the quickest dispatch possible, and this they do with the aid of the electric light. When an engineer is called upon to install or take charge of an electric light plant, it will be well for him to insist pretty closely not only that all the materials specified in the estimates have been shipped, but that every class of tool requisite for constructional work is included. Much time is lost and much trouble is made when you find that your outfit does not include "climbing spurs" or draw vises and other important articles. I have known engineers who have had expensive testing sets, Wheatstone bridges, reflecting galvanometers and other delicate instruments sent out with them, and then found that they had few or any tools to work with, and that the nearest hardware store was many miles away through a rough country, and even then, the store when reached did not contain the requisite goods, there having been no stock kept because there was no demand made for them. Spare armatures, complete sets of arc lamp apparatus, as well as duplicate parts of dynamos, spare brasses and gear for engines and tubes for boilers should always be included, and it should be seen that they are shipped.

Apart from the vicissitudes incidental to life in the tropics, there is, I think, always a satisfaction and pleasure in the successful completion of an installation, knowing as one does that it is a potent factor in the greater civilization of those countries, demonstrating to the inhabitants, who have heretofore depended on artificial illumination of the same primitive character and manner as their forefathers used through ages past, what science aided by her lieutenants "pluck and energy" can accomplish.

Fire Insurance and Electric Interests, From the Underwriters' Standpoint.*

BY S. E. BARTON.

At the Annual Meeting of the National Board of Fire Underwriters in New York, on the 8th of this month, several very interesting papers upon important topics affecting the welfare or ill-fare of the business, were presented.

An extract from the newspaper reports of that meeting reads as follows: "The most interesting report came from the committee on lighting and heating, read by Chairman John H. Washburn. 'The great problem before us to-day,' he said, 'is the management of the various systems of electric lighting, which is not the harmless thing we had imagined, but a most prolific source of danger. It has come to stay, however, and in time it will probably be as safe as any light in use.' With the report a graphic diagram was handed in, which showed that while electric wires and lights were responsible for losses of only $460,000 in 1886, the value of property injured by fire which could be traced to the same source in 1889 was $5,533,000."

Such a report, coming from such a body, representing, as its name implies, the fire underwriters of the nation, conveys to the public the idea that "the relation between fire insurance and electric interests, from the underwriters' standpoint," is a very gloomy one for the former.

I was sorry to see such a bald statement go forth without any explanation as to how it was arrived at or what it indicated. If it was intended to indicate, as it certainly does to every person not acquainted with the facts, that the danger of fire from electrical causes had grown to be twelve times greater in 1889 than it was in 1886, it is shamefully unfair, because it is untrue.

As the figures given are identical with those contained in the "Chronich Fire Tables," published by the Chronich Company, of New York, I presume they came from that publication, and therefore it is fair for me to draw from the same source to show how unfair the report really is.

Those tables show that in 1886 there were 29 fires from "electric wires and lights," causing loss of $460,000; in 1887, 66 fires and $681,000 loss; in 1888, 91 fires with $1,587,000 loss, and in 1889, 74 fires with $5,533,000 loss.

The yearly increase in the *number* of fires reported up to 1888 is nowhere near the percentage of increases in the use of electric lights and wires, while there is a decrease of 24 per cent. in 1889 as compared with 1888, and therefore the *number* of fires was not used to show the comparative hazard by years. It looked much more startling to use the amount of loss, and for that reason I presume it was used; I can see no other reason for using it. But where did the great increase in amount of loss come from? Why, from the Boston fire last Thanksgiving Day which "everybody says was caused by electric wires," but which *nobody* has proved.

The Fire Marshal of Boston in his investigation exhausted his energies and all means at his disposal, and certainly the bulk of the testimony taken would naturally lean toward fixing the cause upon the electric wires. The Massachusetts Insurance Commissioner, referring to that fire in his 1889 report just issued, says "the preponderance of the testimony seems in favor of the theory that it was caused by the electric wires;" therefore, in his opinion (which is good enough for me) it is a "theory" that confronts us and not a condition nor a fact. That loss amounted to about three millions and a half. That sum was injected into the destruction account of "electric wires and lights," making the account four times as large as in 1888; and yet admitting the right to charge the fire to that account at all, it only increased the number of accidents by one. Supposing the fire had got still farther beyond the control of the firemen, and had destroyed one hundred millions instead of three and a half, of course it would have proved (according to the logic of the report of the National Board) that electricity is twenty-two times as hazardous as the report makes it out to be. The official report of the big fire at Lynn says it was caused "by a draft from an open door blowing the blaze from an oil stove down around the burner, causing the stove to explode." The loss by that fire was about four and one-half millions, and I presume it should be charged in equal proportion to open doors, drafts and oil stoves. Two fires were reported in Massachusetts last year as caused by "reflected rays of the sun." If they had destroyed five and a half millions of property the combination of the sun and a reflecting surface might fairly be regarded as a most prolific source of danger. In the language of the report to which I have referred, I am compelled to say that the committee that made it "is not the harmless thing we had imagined, but a most prolific source of" misrepresentation. Let me bore you with a few figures from the Massachusetts "Insurance Report," referred to, as to causes of fires. They are the official returns from all the towns in the State, and cover the period of 1884 to 1889, inclusive.

Broken and exploded kerosene oil lamps and lanterns:	
Number of fires in 1884	136
Number of fires in 1889	217
Increase of 1889 over 1884, 59½ per cent.	
Explosions of gas:	
Number of fires in 1884	4
Number of fires in 1889	8
Increase of 1889 over 1884, 100 per cent.	
Careless use of matches:	
Number of fires in 1884	45
Number of fires in 1889	90
Increase of 1889 over 1884, 100 per cent.	
Children playing with matches:	
Number of fires in 1884	78
Number of fires in 1889	116
Increase of 1889 over 1884, 49 per cent.	
Ignition of curtains and goods by gas and candles:	
Number of fires in 1884	42
Number of fires in 1889	38

Decrease in 1889 from 1884, 10 per cent.; and this decrease is doubtess due to the fact that the incandescent lamp is rapidly replacing the gas jet and candle in windows and stores.

In 1884 "electric wires" caused 6 fires, and in 1889, 7; increase of 1889 over 1884, 16⅔ per cent.

Total number of fires for the whole six years from each cause is as follows:

Broken and exploded lamps and lanterns	947
Explosion of gas	28
Ignition of curtains and goods by gas and candles	253
Careless use of matches	447
Children playing with matches	473
Electric wires	42

Besides these, during the same period 25 fires came from gas and candles near wood-work, and 1884, 1885, and 1887 are not included, as they were not reported.

Lightning caused 208 fires; plumber's pots, 27; thawing water pipes, 89; tramps, 54.

There appears to be none charged to the much despised "tramp wire," unless he was the means of conducting the subtle fluid in some of the 42 cases against electric wires.

Cigar stubs in wooden spittoons caused 41 (1884 and 1885 not reported).

Smoking caused 233 fires, to say nothing of the 3,024 marked as "unknown," many of which were doubtless due to this "most prolific cause," and yet "the management of the various systems" of smoking is not regarded as "the great problem" before the fire underwriter of to-day.

He smokes day in and day out, perhaps causing his own share of fires, and yet he looks with increasing alarm upon a system of distributing light and power for the benefit of mankind, that has only been charged with causing 42 fires in Massachusetts in five years, as against 233 from smoking.

Let me step outside the confines of my little native State and give you a few comparative figures for the whole country, taken from the Chronich Fire Tables for the year 1888. (I have used 1888 instead of 1889, because I happen to have them more handy.) I have selected a few classes of risks in which electric lights and wires are probably more generally used than in others.

In clothing stores the whole number of fires reported for the year is 1,072; 28 of which came from gas jets, 21 from lamps exploding, nine from lamp accidents, three from gas explosions, 13 from matches—in all 74, as against six from electric lights and nine from electric wires.

In country and general merchandise stores 4,847 fires are reported, of which 39 came from lamp explosions, eight from lamp accidents, three from gas jets, 20 from matches—in all 70, as against one from electric wires.

In crockery and glassware stores 179 fires are reported, of which eight came from lamp explosions, seven from lamp accidents, three from gas jets, four from matches—in all 22, as against one from electric wires.

In dry goods stores 1,858 fires are reported, 123 of which came from gas jets, 34 from lamp explosions, six from lamp accidents, seven from gas explosions, 19 from matches—in all 197, as against 10 from electric wires and three from electric lights.

In fancy goods stores 519 are reported, 28 of which came from lamp explosions, seven from lamp accidents, 27 from gas jets, nine from matches, two from candles—in all 73, as against four from electric wires.

In the United States in 1888 the whole number of fires from the above named causes is reported as follows: Lamp and lantern explosions, 528; lamp and lantern accidents, 190; gas jets, 179; gas explosions, 63; matches, 592; in all 1,552, as against 91 from electric lights and wires.

There were 53 from stationary engines and boilers; and that number, though small, can be reduced just as fast as the electric motor takes the place of the boiler and stationary engine.

In the matter of insurance upon electric generating stations, the great problem is practically settled, and it has been settled by the establishment of an Electrical Mutual Insurance Company, organized for the prime purpose of improving and insuring such risks. There is no trouble whatever to-day in procuring ample insurance in the strongest of stock or mutual companies, provided the Electrical Mutual carries a part of the risk, and I predict that within one year companies that have heretofore frowned upon an offer of insurance on the best of such risks, or have charged excessive rates, will be competing for the business. The one truth contained in the extract of the National Board report, namely, that the "business has come to stay" together with the fact that the owners of stations are willing to take their own risks by insuring in a company of their own, has inspired many of the underwriters with courage who were previously possessed of fear and doubts.

Of the 13 fires that were reported in electric light stations in 1888, 11 were from exposure to other risks; four were from unknown causes; five were from causes not reported: one each from engine, furnace, spontaneous combustion, lightning and explosion, while six came from "electric wires;" showing that after all it is not the mysterious electric current, nor the pranky wire, that are responsible for the havoc, but that the ordinary causes that pertain to other risks, such as improper location contiguous to bad neighbors, and carelessness of various kinds, are the chief sources of danger.

In seven years previous to and including 1888, eighty fires are reported in electric light stations—about 11 per year on the average.

On the whole I don't know what the relation between the interests is, from the underwriter's standpoint. What are his views to-day may not be to-morrow. There is no hazard that underwriters, as a rule, have made so little effort to understand; and consequently they are too largely guided by the caprice of popular prejudices and belief, neglecting to study carefully their tables of experience and to be guided by the logic of events. There is also no hazard around which they have ever thrown so many restrictions. Those of us who know what peculiar and impossible conditions must exist in order that the "electric wires" cause fire, can only look on with hope. Enlightenment comes slowly but surely, and the day is not far distant when the large majority of fire underwriters, forgetting their present ideas, will say, "I have always maintained that it was the safest kind of light and power." In the meantime the present rapid development will go on regardless of the "underwriters' standpoint." A few years ago his favor or opposition meant easy or slow progress for the electrical pioneer, because the first question asked was, "how will your wires and lights affect my insurance?" But the business has "come to stay," and that question is less frequently asked.

The same difference, however, exists to-day that always did exist between good and poor installation, and therefore it should be the aim of the electrical men to seek the co-operation of the underwriters in securing the observance of safe fundamental rules.

* Paper read before the Electric Club and their guests, the Engineers, Parker House, Boston, May 21.

Magnetic Data of the Sprague Street Car Motor.*

BY H. F. PARSHALL.

Figures giving the ratios of the lines of force through various parts of the magnetic circuit to the lines of force through the armature have occasionally been fully published, the most noticeable being those given in a paper by Hopkinson some years ago. These ratios vary in the same type of dynamo or motor with any change of proportion;

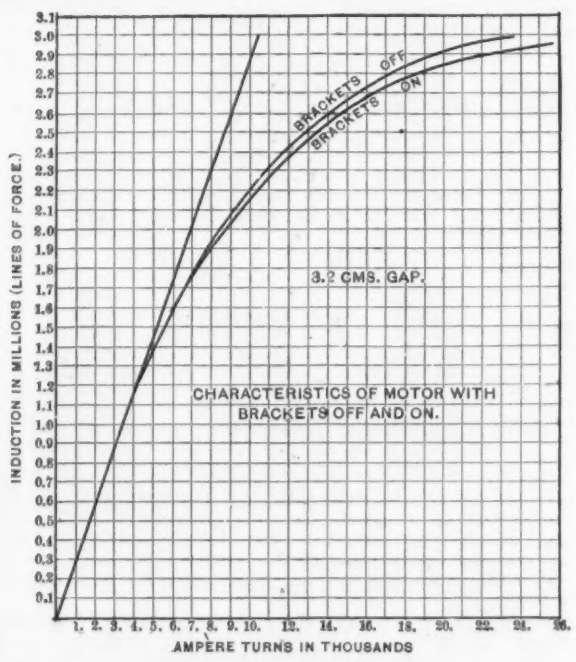

BRACKETS OFF
BRACKETS ON
3.2 CMS. GAP.
CHARACTERISTICS OF MOTOR WITH BRACKETS OFF AND ON.
INDUCTION IN MILLIONS (LINES OF FORCE.)
AMPERE TURNS IN THOUSANDS

Fig. 2.—Characteristic With and Without Bracket.

or, to put it in another way, in order that these ratios may remain constant in the same type, the ratios of the magnetizing force in the one part of the magnetic circuit to the magnetizing force in the other parts must also remain constant.

In making calculations on various motors made by the Sprague Company, I have found it necessary to confirm the assumed values of these ratios by measurements. It is the object of this paper to give the results of measurements made on the street car motor, together with sufficient description to make the values found of some use to those engaged in similar work. If I had had any intention of publishing these results, I should have endeavored to make them, in some ways, more complete than they now are; but so little detailed information exists on this subject, that I have decided to give the result of my work to date on this particular motor. The conditions under which this work has been carried on have not at all times been the most favorable for accuracy, but in the main, the results have been satisfactory.

Fig. 1 shows the various peculiarities of the magnetic circuit, and gives dimensions of the several parts. The most noticeable points are:

The bell-mouthing of the pole pieces shown in the section *A B A*. This bell-mouthing greatly lessens the

* A paper read before the general meeting of the American Institute of Electrical Engineers, Boston, Mass., May 21, 1890.

sparking, as does also cutting away the tips of the pole pieces, as shown in *A B*. With these modifications the brushes can be shifted an angle of 20 degrees without serious sparking.

The other noticeable points are the cast-iron side brackets, the width of the yoke, and its comparative thinness.

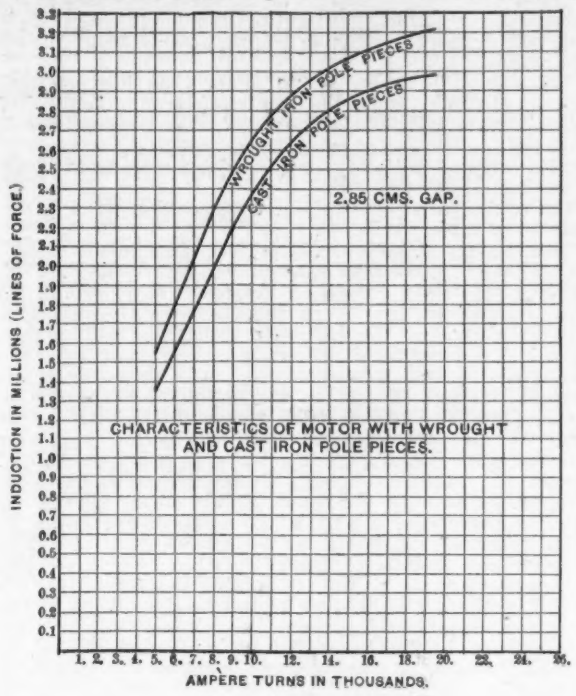

WROUGHT IRON POLE PIECES
CAST IRON POLE PIECES
2.85 CMS. GAP.
CHARACTERISTICS OF MOTOR WITH WROUGHT AND CAST IRON POLE PIECES.
INDUCTION IN MILLIONS (LINES OF FORCE)
AMPERE TURNS IN THOUSANDS.

FIG. 3.—CHARACTERISTICS WITH FORGED AND CAST POLE PIECES.

The method of getting the ratio of the lines of force in one part to the lines of force in another was the usual one. Coils of a few turns were wound around these parts, and connected to a ballistic galvanometer, and when the needle was standing at zero a known magnetizing force was suddenly reversed.

The galvonometer used was an Edelmann with a heavy ring form of needle very slightly damped. The deflections being small, it was assumed that the first throw was proportional to the induction through the measuring coil. The magnetizing coils were those commonly used on this motor.

Each coil was wound approximately to a depth of 4 centimetres, and along the cores 8.5 centimetres.

Coils were as follows:

First—Nearest the pole piece 28 turns per layer, 11 layers.

Second—31 turns per layer, 11 layers.

Third—31 turns per layer, 13 layers.

This gives 2,104 turns for both cores, or with a current of 6.75 ampères, which was used throughout a magnetizing force of 14,200 ampère turns.

By noticing the curves in Fig. 2 it will be seen that this is the part of characteristic upon which the motor is most frequently worked. With different values of magnetizing force, different values of the ratios would be found. This becomes evident when we remember that the resistance of the gap remains constant, while the resistance of the iron increases with the magnetizing force. For this reason the curves of magnetization of the *different* parts of the magnetic circuit are not given.

The measuring coils were 4 turns of wire wound around the armature core at *E. F.*, on the pole piece; at *A. B.*, on the magnet core, midway between the ends and on the yoke at *G. H.*, had it been possible a coil would have been wound around both the yoke and side brackets.

The following values were found:

Lines through magnet / Lines through armature	1.45
Lines through middle of yoke / Lines through armature	1.27
Lines through middle pole piece / Lines through armature	0.666

Cast iron pole pieces:

Lines through magnet / Lines through armature	1.52
Lines through middle of yoke / Lines through armature	1.33
Lines through middle pole pieces / Lines through armature	0.7

The effect of the leakage from the side brackets is shown in Fig. 2, the upper curve being the characteristic with them removed, and the lower curve being the characteristic with brackets on. The dropping of the curve shows that the magnet cores are sooner saturated with the brackets on. The difference is small. It would be somewhat greater did not the brackets reinforce the yoke. These curves were first obtained by separately exciting the fields, and taking the number of revolutions, with a driving current of one ampère through the armature.

The lower curve has, by comparison, been found to be a close approximation to the characteristic when the armature is run with currents for which it was designed.

Fig. 3 shows the characteristics of two motors, one with the wrought-iron pole piece, and the other with the cast-iron pole piece, the gap being 2.85 instead of 3.2, the side brackets being on in each case. The difference between these two characteristics is somewhat striking, and carries its own lesson.

I wish here to acknowledge my indebtedness to Mr. G. J. Scott for the assistance he has given me in making measurements.

The plate shows two forms of pole piece; one has a full line. This is the cast iron; the dotted line shows the wrought iron pole piece.

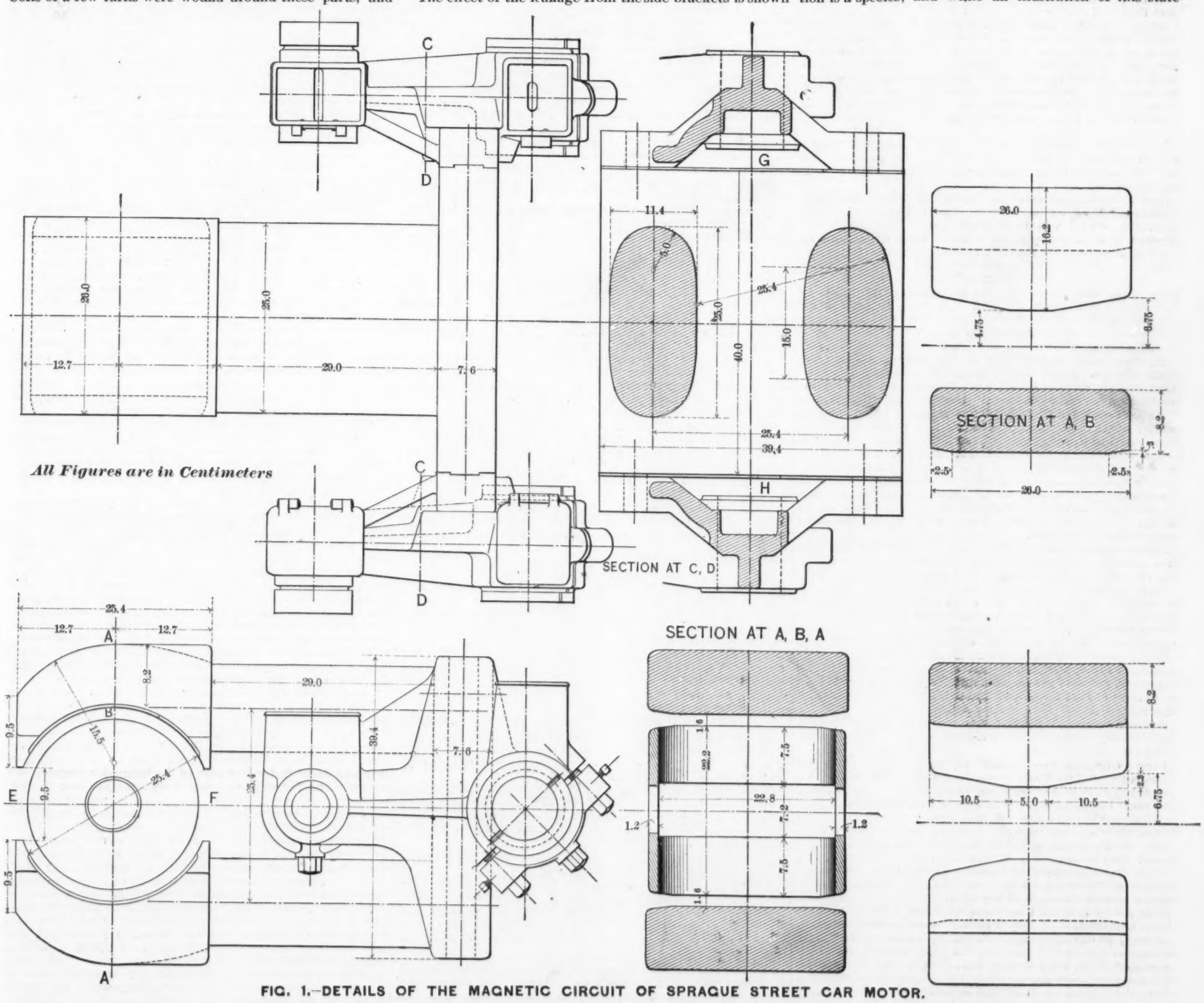


FIG. 1.—DETAILS OF THE MAGNETIC CIRCUIT OF SPRAGUE STREET CAR MOTOR.

The Industrial Utilization of the Counter-Electromotive Force of Self-Induction.*

BY THOMAS D. LOCKWOOD.

It may as well be confessed at the outset that although my production has cost me considerable thought, it does not claim to advance any original ideas. Its claims to attention are based solely upon its merits as a chronicle. There seem to be among the modern race of electricians not a few who regard that species of counter-electromotive force which is the subject of this paper as being the only species in the genus. While, of course, this view is erroneous, it is easily accounted for by the notorious fact that the American electrician as a class has little time to study. The fact, however, while it is indeed as I have termed it, "notorious," is still to be deplored; for it is certain that were electricians fully informed not only of the researches which took place before their own, together with the results of the said researches, whether these results took the form of success or failure, there would be much less valuable time wasted in supposed original research; there would be far fewer valueless inventions produced, and there would be a much smaller amount of subsequent vexations and useless litigation.

While counter electromotive force, generally speaking, is a genus, the counter-electromotive force of self induction is a species; and while an illustration of this statement will no doubt to most of us be an operation something in the nature of carrying coals to Newcastle or water to the Mississippi Valley, I cannot believe that it will be a waste of time, since doubtless we have many members who have not fully considered the subject.

* A paper read before the General Meeting of the American Institute of Electrical Engineers, Boston, Mass., May 21, 1890.

Consider for a moment a definition of electromotive force. What shall we say it is? It certainly is not a natural force like gravitation, and I do not think we can do better than concede that we call it a force simply because it is convenient so to do, and define it as any agency tending to set up that form of motion or vibration which we call electricity, or, if you please, any agency tending to the manifestation of electricity.

We are constantly hearing that a current of electricity is the result of a difference of potential between two points connected by a conductor, but though this statement through constant repetition has come to be as it were "human nature's daily food," I am inclined to consider it as being after all but a mathematical way of saying that a current of electricity is the necessary result of an electromotive force provided with closed conducting circuit. For it is the electromotive force which first determines the difference of potential, which, therefore, may be considered as being a kind of initial result. Following out this train of thought, it appears then that electromotive force is a function of the source or instrumentality which develops the current, and expresses the totality of difference of potential in the entire circuit; and while we may properly speak of the difference of potential, or fall of potential between any two points on the circuit, I think we cannot with equal propriety speak of the E. M. F. in any other way than as something pertaining to the source.

And further consideration of the same idea shows the incorrectness of the popular phrase often used of late years even by many eminent and able electricians, "a *current* of so many *volts*," the electromotive force being in no sense, near or remote, an attribute of the current.

To run counter to anything is to run against it, to run in opposition to, to act opposedly, and so a "counter electromotive force" may be defined as any agency tending to develop a current of electricity in a circuit, opposite in direction to that of the current excited therein by the initial electromotive force.

A familiar instance is that of connecting up in an electric circuit a certain number of cells in opposition to a number of other cells. This constitutes a primary counter-electromotive force and its inclusion in the circuit reduces the current in two ways; first, by reducing the acting electromotive force to a value equal only to the algebraic sum of two opposing forces; and secondly, by adding internal resistance of the value of the cells added in opposition.

Another familiar illustration is found in that ingenious class of dynamo regulators, which acts by causing the opposing brushes to creep around the commutator and according to the work which is being done in the external circuit, to include in the circuit (by increasing or decreasing the lead of the brushes) a greater or less number of armature coil sections exerting an electromotive force in opposition to the electromotive force which is developing the working current.

In these cases a utilization is made of counter-electromotive forces deliberately organized for the purpose, but they are not counter-electromotive forces due to self-induction.

At a very early period in the history of voltaic electricity it was discovered that there was some deteriorating force at work in every voltaic battery which depreciated the current to a much greater extent than exhaustion of the liquids or consumption of the solid elements could account for; and in 1801, Gautherot found* in this phenomenon, which has foolishly been called "polarization," the germ of the secondary cell. He discovered that wires of platinum or of silver which had been used to decompose salt water acquired a power of themselves, yielding a current when placed in acidulated water, and could cause muscular contractions of a frog's leg and produce the galvanic test. And subsequently it was ascertained that the operation of a voltaic battery tended to coat the negative plate with hydrogen, which tended to set up a counter-electromotive force between the hydrogen and the surface of said plate, which thus reduced the available energy of the battery, and that this action could be transferred to the electrodes of the same battery, if placed in a separate decomposing cell, and there tended to form electrically opposed surfaces which could themselves be used to develop a current in a direction opposite to that of the original current. As we all know, this operation, long regarded only as an unmitigated evil, is now utilized in the formation and operation of cells adapted for the electrical storage of energy.

The counter-electromotive force of self-induction distinct from the foregoing, is that discovered by Professor Henry; and its most important use is that which has been mainly brought out in association with the employment of alternating or other currents for the purpose of regulation. By reason of the fact that this utilization has proved to be overwhelmingly important, the electrical fraternity has partially lost sight of many earlier and contemporary instances of the useful employment of self-inductive electromotive force; which is indeed a close analogue in its character, mode of generation, and capabilities of use in regulation to that developed and utilized in the operation of electromotors.

First—I desire to point out that though Henry was the first to study and discuss self-induction, he was not the first to notice its effects.

Until quite recently I, together with nearly everyone else, had supposed that the earliest published notice of this phenomenon was Henry's account† of his observation, published in 1832; but I have in my researches on this subject dug out the fact that this is not true. I find that an experimentalist, Vassali-Eandi by name, records‡ that with a pole of fifty pairs he found that the fluid passed along a copper wire plated with silver, 1,151 feet in length, in a time incommensurable; the shock in this case was three times as strong as that experienced by immediately touching the two extremities of the pile.

The above isolated statement of facts I believe stands alone, and there is no record that it led to further research.

Henry, on the contrary, perseveringly pursued and made himself master of the subject; and the record of his original observation, brief though it is, details the appearance of a vivid spark on the breaking of a battery circuit, if a wire 30 or 40 feet in length be included in that circuit; shows that the effect is increased by coiling the insulated wire into a helix; and that the effect depends in some measure on the length and thickness of the wire. The note concludes with these remarkable words: "I can account for these phenomena only by supposing the long wire to become charged with electricity, which by its reaction on itself projects a spark when the connection is broken."

This, though brief, is then the first analytical notice of the electromotive force of self-induction, so long erroneously denominated after its results, the "extra current."

It is unfortunate that Prof. Henry did not for some time pursue the subject, and we do not hear from him again until March, 1835.

Meanwhile his great contemporary, Faraday, had taken it up pursuant to an observation of one William Jenkin, and showed self-induction to be a corollary of his former masterly experimental researches in magneto-electro induction.

Faraday notes* the following points: "Self-induction exists in simple helices as well as in electro-magnets, though not in the same degree.

"Helices are superior in developing induction to straight wires, and long wires to short ones.

"Self-induction practically disappears when the conductor is permitted to inductively act upon a neighboring closed circuit.

"That the amount of self-induction depends on the length of wire exposed to inductive action.

"An iron core within helices much exalts the action of self-induction.

"The self-inductive effect depends not upon a permanent state of the core, but on a change of state."

Henry now again takes up the matter, and in a consecutive series of papers practically runs it to earth.

In a paper† of March, 1835, he gives more in detail some of the conditions of the development of self-induction. A long wire is better than a short one; a helix better than a straight wire of equal length. He also describes a shocking coil, and also a deflagration coil of but one wire in which self-induction is involved.

A little later‡ he elucidates the origin and properties of self induction and records that some additional energy appeared when iron was used as a core, but not much, because his coils were flat and not elongated helices. He ascribes all of these effects to dynamical induction, and shows that in a coil of a number of convolutions the convolutions act inductively on each other, and inferentially that the energy of the self-induction is the sum of that of the different coils.

In a third paper§ further experiments in self-induction or with the extra current, as it was then called, are discussed. We learn that the E. M. F. of any self-induction coil within certain limits is dependent upon the length of the coil, and that the form of the coil has considerable influence on the intensity of the action. In the experiments of Dr. Faraday, a long cylindrical coil of thick copper wire inclosing a rod of soft iron was used.

This form produces the greatest effect when magnetic reaction is employed.

The "extra current" of self-induction developed in a coil, is controllable by the presence of an immediately adjacent independent coil. It is energetic when the circuit of the adjacent coil is open, but absent when the adjacent circuit is closed.

Of course it is impossible in this paper even to indicate the many good things which are spread before the reader of the researches of both Faraday and Henry. They are well worth study, and in fact they laid a solid foundation for the work which is being done now.

Both discovery and invention are displayed in their work, much of which has only found its sphere of action within the last four years; for it is emphatically true, as has been said by Mr. W. H. Preece, "that though we are accustomed to hear that necessity is the mother of invention, the child is as a matter of fact often born before its parent."

As is frequently the case with electrical discovery, self-induction was for long recognized, that is, for the most part, and by the generality of electricians, only as an unwelcome guest whose parting was to be speeded.

It was manifested mainly by an undesirable spark appearing upon the break of electric circuits in telegraphic, scientific and medical apparatus, and tending to burn away or oxidize contact points; while in the case of the two-wire induction coils its effect was to reduce the spark passing between the terminals of the secondary; and many have been the expedients, wise and otherwise, which were devised for its banishment. Many of these were patented; more were not; inasmuch as the fever for patenting everything from a solar system to a thought had not then come into fashion.

Examples of this class of expedient are respectively:

British Patent, No. 12,772, September 20, 1849, granted to those old heroes of electric lighting history, Staite and Petrie, which has for its 18th clause, a mode of "preventing the spark when breaking contact in galvanic circuits. A thin platinum wire may still convey some portion of the current after the main circuit is broken, or a series of sufficiently long conductors may break contact one after the other." The preferred way, in plain English, was to connect a fine wire as a shunt round the break, and thus to furnish a closed circuit in which the self-induction circulated its current of breaking.

United States Patent, No. 33,269, granted to J. E. Smith, September 10, 1861, for a means of preventing the spark between the local points of a relay on breaking the circuit; shunting the break by a wire having two terminals dipping into a bottle of water.

Moreover, as is well known, in the ordinary induction coil the action is emphasized by shunting the primary break by a condenser as first suggested by Fizeau.‖

This, as I shall point out later, is a real instance of the industrial utilization of self-induction.

Other early investigators in this line reduced the spark of breaking the circuit by wire shunts also.

Although, as I have stated, the recognitions of self-induction were mostly recognitions of an adversary, there were one or two early instances where the enemy was subjugated, and made to expend his energy usefully. The most notable instances of this are the single wire spark coils of Page and Callan* which were made especially with a view to exalt the self-inductive effects and with which metals were fused and electrolytes were decomposed.

These were the forerunners of the spark coils used at the present day in electric gas lighting, and comprising a single long coil wound to a suitable length upon a long core of iron wires.

There can, however, be no doubt that the principal attempts to make useful the counter-electromotive force of self-induction, and likewise the principal successes achieved, have been in the line of controlling, regulating or modifying the original, initiatory, or primary currents from which it has been developed.

I have compared this to the transposition of a given number of battery cells.

This analogy is, however, imperfect; since in cells of battery we may for the sake of argument regard the E. M. F. as being practically constant. Certainly they will in no sense regulate themselves in accordance with conditions automatically, but the inductive resistance *will* do this, for it is dependent for its efficiency as a generator upon the strength of current flowing through it. Therefore, if the current through it, due to the impressed electromotive force, from any reason falls, the counter-electromotive force will also diminish, and thus will permit a greater amount of the initial force to act; or, in other words, will permit the impressed energy to become more effective. Suppose we have in the main circuit of an alternating dynamo, supplying a number of incandescent lamps in bridges uniting its mains, an adjustable resistance, and suppose the inductive resistance, which we may also regard as a counter E. M. F. generator, to be initially adjusted, so that all of the lamps burn brightly, then within limits of considerable range the current will be kept steady, even though the applied E. M. F. fall or rise, or though the external resistance of the circuit be varied by lighting or extinguishing lamps.

For if lamps be extinguished and their branch circuits be opened, the external resistance rises and the current falls. It is true that the reduced current has not now so many branches to divide through, and that therefore self-regulation even without counter E. M. F. might be expected; but in systems of considerable magnitude it is not found to act practically as well as it theoretically should. But here the useful effect of our self-induction regulation comes into play; and since the current acting upon the regulator is lowered, it is caused to develop a counter E. M. F. of less value, and thus to oppose less energetically the applied E. M. F., which therefore is brought to a greater extent into action, to overcome the increased resistance, and to maintain the normal current for the remaining work. So, if the applied potential falls, the current in consequence falls with it, and the counter E. M. F. developed falls also, and enables more of the applied E. M. F. to come into action. And the converse is true if the current in the circuit from any other cause rises. Such an appliance would be still more convenient in connection with an arrangement of arc lamps fed by alternating currents and connected up in parallel circuit, since the resistance of arc lamps would constantly be changing.

This has been so prominently brought before us by its most modern employment, namely, by its well-nigh involuntary use, in the distribution of electricity by means of alternating currents and transformers or converters having their primaries connected in parallel between the two mains of the source, and by the inductive resistance regulating device patented by John Hopkinson in England, Aug. 3, 1881, No. 3,362, and in the United States, Nov. 5, 1889, No. 414,541, that many persons have actually been led to believe that such use is really a new thing.

The employment in the regulation of electrical distribution, of counter-electromotive forces set up by the working currents themselves and proportioning themselves automatically to the work being done, is one of the most valuable and interesting features of modern electrical work; and though such regulation requires to be supplemented by auxiliary arrangements, and though the belief of some that it could be attained absolutely without any waste has not been completely realized, still by availing ourselves of this feature we are enabled to control electricity with a facility and under conditions which otherwise would be unattainable.

The Hopkinson invention consisted in associating with an arc or glow electric light circuit employing alternating currents a variable inductive resistance. This in one form was made by coiling a ribbon of thin sheet iron into a ring form, the different layers being separated by an insulating layer, and then by winding a number of coils of insulated wire on this ring, their adjacent ends being connected with plates between which contact plugs could be inserted, so that any number of the coils could be introduced or cut out from the circuit. Another form embodied the same principles, but had not a closed core. This form had a horseshoe core made of an electromagnet formed of layers of sheet iron insulated from each other. The legs of the core are surrounded with the coils, and the said core has an armature also made of insulated layers of sheet iron. In this form the armature is clamped down; but the regulability of the appliance is attained by moving the magnet core further into or withdrawing to a greater or less extent from the surrounding coils. The form first described is in the British patent shown as being included in circuit with the two mains of a dynamo, incandescing lamps being in cross bridges between the said mains, while in another figure arc lamps are in parallel circuit with mains, an inductive resistance being included in each branch for each lamp and acting as an equalizer.

The iron core closed on itself to form a complete magnetic ring in which the lines of force are concentrated through the coil and forced to cut all convolutions when exposed to reversals; the laminations at right angles to the currents, acting to facilitate magnetic change, to diminish hysteresis, and to prevent the circulation of eddy currents; and the insulation of the said laminations aiding in the latter function, all tend to show that this is a very highly organized appliance, and is not only well adapted to produce a very high degree of self-induction, but combines most of the best arrangements tending to that end; and it is therefore not surprising that its invention and use made a strong impression upon the electrical mind and caused a revival of the idea that regulation on these lines was capable of being accomplished, to use the words of the patent, "without wasting energy." Without materially wasting energy would perhaps be more strictly accurate, for by its use a small amount of actual resistance coil is enabled to do the work of a very much larger amount.

I have certainly no desire to detract from the great

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* See Izarn's Manuel du Galvanisme, Paris, 1804, and Phil. Mag., 1806, Vol. XXIV., p. 185.

† Silliman's American Journal of Science, July, 1832. Vol. XXII., pp. 403-8.

‡ Philosophical Magazine, Vol. XV., 1803; a s Phi . Magazine, Vol. III, 4th ser. 1852, p. 455.

* Experimental Researches in Electricity, Faraday, 1839, Vol. Ninth Series, pp. 332 343, read before the Royal Society, Jan. 29, 1835. A series of notes, "The Influence by Induction of an Electric Current on Itself."

† Journal of the Franklin Institute, March, 1835, Vol. XV. pp. 169—170. Silliman's American Journal of Science, July, 1836, Vol XXVIII, pp. 327 and 331 and Scientific Writings of J. Henry, Washington, Vol. I, pp. 87-91.

‡ Transactions American Phil. Soc., N. S., Vol. V, pp. 223-231, reprinted in Sci. Writings, J. Henry, Washington, 1886, Vol., I, pp. 92-100.

§ Transactions of American Phil. Soc. Vol. VI. pp. 303-337, Nov. 2, 1838. Silliman's American Journal of Science, March, 1840, Vol. XXXVIII pp. 209-243, Scient. Writings of Joseph Henry, Washington, 1886. Vol. I, p. 108.

‖ Comptes Rendus, Vol. XXXVI. p. 418, 1853.

* Sturgeon's Annals, Vol I, pp. 290-302.

merit of this application, but an honest chronicler has no choice and must say what has been done, and it must, therefore, be stated that inductive resistances and other self-induction appliances had long been used both experimentally and commercially, no doubt often with but an imperfect conception of their mode of operation.

Poggendorff's researches* into the action of induction coils disclose a remarkable state of affairs for so early a date. These show that one induction coil was employed to send a current through the secondary helices of two others. The first coil thus acted as an alternating generator, and the two others as inductive resistances.

The primaries of two induction coils were connected in parallel and also in series at different times. When, to quote Poggendorf's own words: "Two instruments (induction coils), A and B, were so combined that the current traversed the two primary coils one after the other, the induction coils (secondaries) however were separated and A was allowed to give sparks, while B remained unclosed and without a soft iron core; the introduction of the latter into B, weakened the sparks of A, and the subsequent metallic closing of B reproduced their former strength."

The proper arrangement of induction coils is then discussed, and whether the primaries should be connected in series or in parallel circuit. It is shown that the latter way is the proper one, and why. Then the paper goes on to say, "With respect to the cause of these phenomena it is no doubt to be sought in the extra or inner induction current. The outer induction current, which is produced by breaking the inducing current, has the same direction as the latter; whereas the extra current, which is at the same time excited in the induction wire, whose tendency is to weaken the first induction current, and the more so the stronger the extra current, which latter is especially strengthened by the soft iron core.

"Consequently when the primary coils of A and B are connected one after the other, it is clear that the insertion of the soft iron core into that of B will strengthen the extra current in that of A, and therefore weaken the induction current of the latter instrument.

"By connecting the instruments side by side a closed circle is at once formed by them, and the extra current produced by the insertion of the soft iron core into B acts against that in A, and may therefore, when both are equal, completely neutralize it, when the outer induction current of A will necessarily be strengthened.

"Without the circle formed by this combination, *i. e.*, in the wire leading back to the voltaic battery, the two extra currents act of course in the same direction and strengthen one another, in consequence of which the sparks at the current breaker are still very active."

These considerations of Poggendorff show that even at this early period a great flash of light was thrown into the darkness which hitherto had obscured the reactions of self-induction, and though we have largely failed to use that light until quite recently, this is chiefly attributable to the same oft recurring reason, that there was really little call for it; hence it was soon hid under the bushel of the results of research on other subjects of more immediate interest.

The statement which I last quoted brings me again to the application by Fizeau of the condenser as a shunt to the vibratory break, and to its operation.

As shown by Lord Rayleigh,† the condenser operates by producing electrical oscillations, and in its action the spark at the contact breaker is greatly decreased and the spark between the secondary terminals greatly magnified, because at the break the condenser is virtually an inductive reservoir, being an electrostatic shunt. And being an electrostatic shunt, the energy it momentarily absorbs is returned reversely to the primary circuit, just as in the discharge of a secondary cell, and increases the inductive variation in the secondary circuit during the brief period of time immediately after the break. And as the electromotive force in the secondary is thus exalted it is not difficult to see why the condenser increases the sparking distance.

As early as Dec. 6, 1862, a patent for cable working, No. 3,453, was taken out by C. F. Varley, which describes the use of a self induction resistance. This patent says: "A second circuit from the cable to the earth independent of the receiving instrument is formed by means of a resistance coil with a large iron core. It may be advisable to connect the cable to earth through an induction coil, consisting of a large bundle of iron wire, surrounded by a long length of fine wire, the action of which is as follows: On reversing the battery connections the induction plates (condenser) and battery combined send a short impulse into the cable, which divides, one portion into the cable, the other through the induction coil to the earth. At the first moment the iron of the core opposes the passage of the current, consequently during the first instant of time nearly the whole force of the current is applied to the cable. As the iron becomes magnetized to its maximum, this opposition ceases, but the plates have been changed in the opposite direction, and there is no longer any current passing from them into the cable to maintain the magnetization of the iron, the demagnetization of which induces a current in the coil, and discharges the cable. In this way each impulse is followed by a short impulse in the opposite direction. One of the figures of the patent shows that the wires of the core are made long, and are turned back on all sides over the wire of the coil, so as to entirely encase it. This feature was in conformity with a previous British patent, No. 3,059, of 1856. The arrangement, however, clearly shows a use of a self-induction coil as a current controller, and indicates the function of a large iron core.

We next find the counter E. M. F. of self-induction coming into use in connection with fast telegraph systems. Arrangements for its use are shown in the United States patents granted to Mr. Edison. These are respectively, No. 135,531 of Feb. 4, 1873; No. 141,773 of Aug, 12, 1873, and No. 147,313 of Feb. 10, 1874.

The first and second disclose a shunt circuit including an electro-magnet connected round the receiving instrument of a chemical telegraph. The first also shows a leak to earth from the line, which leak includes an electro-magnet. In both cases the object is to utilize the discharge current developed by the electro-magnet in the regulation of the operation and to produce sharp and clear signals.

The third describes the use of electro-magnets in shunt circuits round the transmitting and receiving instruments of an automatic telegraph system, and is said to be an improvement on the first. A number of electro-magnets are shown, and by means of a switch one or more of these may be introduced. In other words, the inductive resistance is here adjustable, and is operated by breaks, not by reversals.

British Patent No. 3,935, Nov. 14, 1874, to Alexander Melville Clark for a chemical copying telegraph, uses induction and other coils to clear a line by the self-inductive counter E. M. F. By the decrement or cessation of the impulse (as the patent states), the strongest depolarizing effects are produced, and the line is successfully cleared.

Next come four other patents to Thos. A. Edison. These are U. S. Patent, No. 168,243, of Sept. 28, 1875, for an automatic telegraph. This, as in the previous cases, employs an electro-magnetic shunt.

U. S. Patent No. 168,385, of Oct. 5, 1875, Duplex Telegraph. This is an excellent example of self-inductive regulation. The counter E. M. F. is developed from electro-magnets in a changing electric circuit, and the coils have cores closed on themselves.

The next two, No. 173,718, of Feb. 22, 1876, for automatic telegraphy, and No. 178,221, May 30, 1876, duplex telegraphy, involve no new principles, and are like the preceding ones.

Much information regarding the subject and further examples of its practical application can be found in a particularly able paper on "Shunts," read by William H. Preece, before the Society of Telegraph Engineers in 1887.* The subject of the counter E. M. F. developed in electro-magnets is discussed, and the increase of the same, when the iron core is endless, is determined and pointed out; a good many instances of the practical uses of the self-induction shunt are described.

U. S. Patent No. 207,724, of Sept. 3, 1878; granted to Thos. A. Edison for a duplex telegraph, shows an electro-magnetic coil and closed magnetic circuit core placed in each branch of a Wheatstone bridge duplex telegraph, to counteract by its counter E. M. F. of self-induction the discharge of the electro-magnets in the bridge circuit. In Culley's Handbook of Practical Telegraphy, London, 1878, pp. 303-304, also pp. 305 and 411, the regulation of currents by inductive resistances is considered.

In the first instance, the counter E. M. F. of an adjustable series of electro-magnetic coils is used to delay the discharge of a condenser in a duplex system. This is closely analogous to the function of the Hopkinson device, and is very suggestive. The reference on page 305 states that "static discharge can be entirely compensated for by the use of an induction coil, or a series of electro-magnets instead of a condenser."

U. S. Patent No. 227,039, of April 27, 1880, to Muirhead & Winter, for a quadruplex telegraph, describes electro-magnetic shunts for reversing keys and relays, which are to counteract by their discharges electrostatic retardation. The specification says "the electro-magnets may be of the well-known closed horseshoe form, or they may consist of a single rod of soft iron, with flanges of soft iron and a cylindrical casing of iron closing over the wire and connecting magnetically flange with flange.

U. S. Patent 231,904, Sept. 7, 1880, to Joseph E. Fenn, duplex telegraph, uses an electro-magnetic generator of counter E. M. F. in the line circuit to counteract effects of discharge. It is made with a closed magnetic circuit, a separate coil being on each leg of a multiple pole core; several of these poles are made with yokes, and the combined yokes can be made magnetically continuous or discontinuous at will by means of iron plugs which can unite the different sections of core.

A book published in 1880, by Louis Schwendler, and entitled "Instructions for Testing Telegraph Lines, and the Technical Arrangements of Circuits," Vol. II., pp. 144-147, gives a description of an electro-magnetic shunt and its operation. It is made like an ordinary electro-magnet, but has an adjustable wedge-shaped armature in contact with the cores. This, of course, operates by utilizing the counter E. M. F. of self-induction, which develops currents that circulate through the shunt and sharpen the signals.

In telephony, also, as in other fast systems employing rhythmical currents, the counter E. M. F. has by no means been idle. As in telegraphy, our early acquaintance with it was an unpleasant one. Many of the earlier telephone lines connected with a number of stations, and at each station there was, of course, an electro-magnet to operate the call. In some cases this was a telegraph relay, and in other cases a bell magnet. But in either case it was found, as, indeed, might have been anticipated, that the telephone currents had a decided repugnance to pass through the intervening electro-magnets on their way from one station to the other. To quote the graphic words of one of the patentees of devices intended as remedies for this trouble, it was found that electro-magnets were to a large extent "opaque to telephone currents."

Of course this is due to self-induction. The resistance of the line or the magnet coils had little or nothing to do with it. The convolutions, however, had, since it is clear that the E. M. F. of the self-induction was proportional within certain limits to the number of convolutions.

The same difficulty appeared also in exchange work, where between any two connected lines was interposed an annunciator, to give from either end station a disconnecting signal. Several devices have been suggested for the removal of this difficulty, and some of them have been patented.

Elisha Gray shunts the several interposed magnets by condensers; vide United States Patent 203,264, of May 7, 1878.

F. W. Jones, attacking the same difficulty, shunts the interposed magnet by a non-inductive resistance controlled by the armature of the signaling magnet. See United States Patents 238,399, of March 1, 1881, and 238,912, of March 15, 1881.

Other devices have also acted to shunt the bell or annunciator magnets in different ways; and still other suggestions have been, to surround the iron core with a brass sleeve, or with a closed circuit consisting of one layer of insulated wire; but these last, while certainly reducing the retardation, reduce also the magnetic power of the appliance. And there is no remedy so effectual as the absence of the interposed electro-magnet.

The service rendered by self-induction in telephony, and that which may be expected, fortunately will probably outweigh the ills which it introduces. In many switchboard installations for metallic circuits, the supervising telephones are looped or bridged across between the two conducting links which unite one of the two metallic circuits with the other, and their self-induction prevents a material loss of current. Where from some condition of the service, such for example as the requirement of supervising both metallic and earth return circuits at the same switchboard, it sometimes becomes necessary in bridging the telephones to attach an earth branch to the connecting link on one side of the instruments, in this case it has also been found necessary in practice to place coils containing iron cores on the other side of the earth branch, so that not only the resistance but also the self-induction may be balanced.

It has also been ascertained that many telephones can at different stations be placed across from one wire to the other of a metallic circuit without any perceptible diminution of the effect at any one of them. This is one of the most important results of self-regulating attribute of self-induction.

Perhaps, however, the most valuable instance of turning an electrical enemy into an electrical ally is the way in which by the proper use, construction and arrangement of electro-magnets, a plurality of either telephonic or partially telephonic and partly telegraphic messages may be transmitted over the same circuit at the same time.

The pioneer in this kind of work was C. F. Varley, who as early as 1870 took out a patent, No. 1,044. in England, for a combined simultaneous ordinary Morse and harmonic Morse transmission over the same wire; in this system the straight Morse was worked through the electro-magnets, while the harmonic branches were led off from the main line from points outside of the electro-magnets.

Carrying on this line of invention, Mr. Van Rysselberghe, of Belgium, and Dr. Rosebrugh, of Toronto, Canada, have worked out systems whereby telegraphy and speaking telephony can be at the same time operated over the same circuit.

Since, however, there is enough in either system to fill up a paper devoted to them exclusively, and since this paper is already too long, I find it impossible here to describe them in detail, reserving this possibly for some future occasion.

Self-induction has also been caused to aid in eliminating the disturbing results of extraneous induction caused by parallel circuits, as in the United States Patent of Mr. Edison, No. 203,019, of April 30, 1878, where a telephone circuit is freed from external influences by combining it with an induction coil connected with the disturbing circuits in such a manner that the direct disturbances received in virtue of the parallelism of the contiguous circuits is neutralized by an equal and opposite induction received also from them through the induction coil. This, however, is not a practical expedient.

Closely analogous to the self-inductive regulation of which I have been speaking, is that upon which the efficiency of an electro-motor depends. This was first observed by Jacobi,* who says:

"Experimenting on the magnetic force of a bar of soft iron for which I could in no way account, I sometimes found considerable differences for which I could in no way account. I was curious to know if these differences proceeded from the nature of the iron or from the weakening of the electric current produced by a voltaic pair of half a foot square of surface. For this reason I placed in the circuit a galvanometer so distant as not to be affected by the direct magnetism of the bar. I was much astonished to see the needle recoil on placing the armature and advance on removing it, for it was the first time I had known the double quality of the connecting wire, viz., that of constructing the voltaic current, and at the same time representing an ordinary wire subject to the action of a magnet in motion. The spiral producing a magnet by the voltaic current is at the same time a magnetic electrical spiral in which a magnet is placed.

"Hence the solution of the uniform velocity of the magnetic machine. For being set in motion by the magnetizing power of a voltaic current, it represents simultaneously an apparatus composed of magnets in motion and capable of producing a magnetic electrical current in a direction opposite to that of the voltaic current."

Jacobi in a subsequent paper practically elucidated the principles of the operation of counter E. M. F. in electro motors, even as now understood, although he possibly did not state them as we now would. But he clearly showed that a motor may be regarded as a dynamo acting to develop an electromotive force, opposite in direction to that acting upon it, E. That the resultant force was of course E-e, and that this together with the resistance of circuit determine the strength of the current. That the motor utilizes C e of the electrical power supplied C E; and he furthermore showed that the power developed by the motor C e is at its maximum when e equals one-half E.

It may be thought by some that, considering the title of the paper, the principal utilization to which I have referred, viz., the use in regulation of systems of alternating currents operating converters, should have been discussed. It does not seem to me that it is necessary; this has often been done, and will again often be done by others much more competent than myself to handle the subject. But it does seem right that one should be found to give due credit for those who, in the same line of thought, are "not lost, but gone before," and I am glad that I am in a position so to do.

There seems little need for me to cite any more instances, showing that like nearly all new arts, the art of regulation by means of self-induction and of otherwise usefully employing the counter E. M. F. due thereto, is not *quite* new, and that while we can congratulate ourselves upon the achievements of the present, we should not fail to respect the foundation layers of the past, for of a truth there were giants in those days.

The Coefficient of Self-Induction of a Single Circular Loop.†

BY OTTO P. BLATHY.

As far as I am aware, the self-induction coefficient of one single circular loop of wire has up to now been developed only in an approximate form; the following deduction resulting into the exact coefficient represented by a closed expression will therefore be of some interest.

Let us put

$O A = R$ $\qquad$ $A B = x$

$A P = \rho$ $\qquad$ $B P = y$

Angle $B A P = a$ $\qquad$ Angle $B A D = a'$

R, radius of wire.

$d s$, element of wire.

The magnetic force at P due to the element $d s$ is given by

$$\frac{i \cdot d s}{\rho^2} \cos. a.$$

* Poggendorff's Annalen, Vol. XCIV., p. 2 and London and Edinburgh and Dublin, Phil., Magazine, 1855, Vol. X 4th series pp., 136-137.

† Phil. Mag. Vol. XXXIX., p. 428, et seq.

* Journal of Society of Telegraph Engineers, London, 1877, pp. 40-69.

* Sturgeon's Annals of Electricity, 1837, Vol. I., pp. 408-419.

† From *The Electrician*, London.

The total induction through the circle of radius R (no magnetic material being supposed in the field) is therefore for the unit current,

$$L = \int\int\int \frac{i \cdot \cos. a}{\rho^2} d x \cdot d y \cdot d s,$$

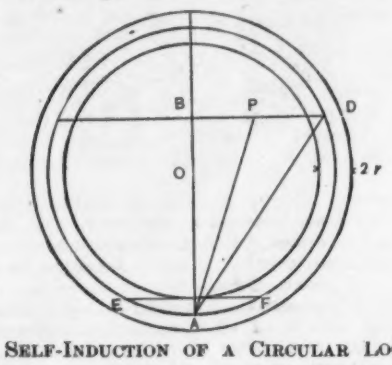
the integrations extending over the area and round the circumference of circle R. Now we have $d y \cdot \cos. a = \rho \cdot d a$ and $\rho \cdot \cos. a = x$, therefore

$$L = 2 R \pi \int\int_{a'}^{+a'} \frac{i \cdot \cos. a}{x} d x \cdot d a = 4 R \pi \int i \cdot \sin a' \frac{d x}{x}.$$

But $$\sin a' = \sqrt{1 - \frac{x}{2R}};$$

then $$L = 4 R \pi \int \frac{i \, d x}{x} \sqrt{1 - \frac{x}{2 R}}.$$

For the space above $E F$ the current i is equal to the



Self-Induction of a Circular Loop.

total current in the wire, that is unity. But for the segment between E F and the axis of the wire we have $\frac{x^2}{i} = r^2$. Therefore,

$$L = 4 R \pi \left[\int_0^r \frac{x \cdot d x}{r^2} \sqrt{1 - \frac{x}{2R}} + \int_r^{2R} \frac{d x}{x} \sqrt{1 - \frac{x}{2R}} \right].$$

Integrating and reducing to the simplest form we get

$$L = 4 R \pi \left\{ \text{log. nat.} \frac{4R - r + \sqrt{16 R^2 - 8 R r}}{r} + \frac{16 R^2}{15 r^2} - \left(\frac{16 R^2}{15 r^2} + \frac{4R}{15r} + \frac{8}{5} \right) \sqrt{1 - \frac{r}{2R}} \right.$$

This is the exact total induction through circle of radius R by unit current in wire of radius r forming said circle. Developing in series we have, as an appoximate expression, $L =$

$$4 R \pi \left[0{\cdot}57944 + \text{log. nat.} \frac{R}{r} - \frac{2r}{R} - \frac{r^2}{24 R^2} - \frac{r^3}{48 R^3} - \cdots \right].$$

The Comparative Cost of Storage Batteries and Horses in Street-Car Traction.

BY PAUL GADOT.

Observations on the output of the plates.—The question of the output of the plates is too important to be passed over without comment. Even under the special conditions obtaining in the construction of traction batteries, it must not be forgotten that there is a mean rate of output that it is not well to exceed, if their deterioration is to be within what we have allowed for in our previous calculations.

In practice the rate will be very variable, on account of inequalities in the road-bed, differences of charging, of grade, of stoppages, etc., etc.; but in order to avoid unnecessary complication, we shall consider only the mean normal work, taking as the average speed of a car 2.638 meters per second, or 9.5 kilometers per hour.

In the case of two groups, if a car made its entire run of 50 kilometers without stop, at this normal speed, the time consumed would be $\frac{50}{9.5} = 5.263$ hours. Since each kilogram of the plates is to furnish 6.92 ampère hours (see F, p. 321), the mean normal output per kilogram of plates is $\frac{6.92}{5.263} = 1.31$ ampères.

The same result would be reached, though not so easily, by starting directly from the force developed for traction; bearing in mind that the mean force per ton moved is ten kilograms; that the mean tension is taken at 1.8 volts; that the coefficients of power returned by the mechanism and the motor in the car are respectively .833 and .75; that the total weight moved in this case is 7.5 + 2.5 = 10 tons; and that the weight of the plates alone is 1,750 kilograms. The output per kilogram of plates would then be

$$\frac{10 \times 10 \times 2.638 \times g}{1.8 \times 1{,}750 \times .833 \times .75} = 1.31 \text{ ampères.}$$

In the case of two groups, therefore, the accumulators, from the point of view of output, work under good conditions.

In the case of three groups, if the car should run the 33.333 kilometres expected from each group, without stoppage, it would take (at the rate assumed, 9.5 kilometers per hour), $\frac{33.333}{9.5} = 3.51$ hours for the run. The normal output per kilogram of plates would therefore be $\frac{6.92}{3.51} = 1.97$ ampères, a rate already somewhat severe.

In the case of four groups, the car would occupy 2.5 hours for its run of 23.81 kilometres; whence the mean output per kilogram of plates would be $\frac{6.92}{2.50} = 2.77$ ampères. This is too high.

And in the case of five groups, the time occupied for the assumed uninterrupted run of 18.2 kilometres, at 9.5 per hour would be but $\frac{18.2}{9.5} = 1.92$ hours. The mean output would, therefore, be, $\frac{6.92}{1.92} = 3.6$ ampères. This is an average rate that is much too violent.

It is well to notice that these results are for average outputs, and that they will be increased, sometimes very considerably, by curves, grades, starting, etc., etc.; but on the other hand, it should not be forgotten that the frequent stops incident to passenger traffic will be very favorable to the depolarization of the accumulators, which will, moreover, be somewhat maintained by the irregular movements of the moving car.

Neither should we disregard the facts that the outputs above calculated are based on the supposition that the car is always full, whereas in fact this is frequently not the case, the difference being sufficient to reduce the output of the plates very considerably, and thus improve the aspect of this branch of the question.

In short, in regard to output, it may be said that the conditions in the case of two groups of batteries per car per day are good; in the case of three groups they are acceptable; four groups give a rate that is too severe and that might cause a greater destruction of the plates than that for which we have allowed; and the hypothesis of five groups must frankly be rejected, as demanding from the plates an output decidedly too violent.

Conclusions as to the automobile motor car.—With one group of storage batteries per car per day, the weight of the accumulators is so great that the system must be discarded.

With two groups, the cost per car per kilometre is .538 fr., and the average output of the plates is suitable.

With three groups, the cost is .507 fr., and the output still acceptable.

With four, the cost is .502 fr., but the mean output is much forced.

With five or more groups the cost of traction becomes greater and greater, and the output of the plates is so excessive as to increase very considerably the cost per car-kilometre.

Accordingly, under the conditions supposed by us, the case of three groups of accumulators per car per day, with a moderate output, and a probable cost of .507 francs per car-kilometre, seems to us most favorable, and most wisely adopted when the circumstances of the case permit. Under other conditions the conclusions reached might vary from ours, since our study has attempted to give approximate for the tramways of Paris, but only to furnish a basis of calculation for other systems.

II. ELECTRIC LOCOMOTIVES.

The independent locomotive is certainly the most attractive solution, at first glance, of the problem of electrical traction; there are no awkward alterations to be made in existing cars, and opportunity is given for constructing a locomotive of whatever design will best suit the circumstances of the case, so as to dispose most conveniently of the accumulators, the motors, the machinery, etc. All this is evidently very advantageous. But in spite of these merits, it will quickly be seen, upon investigation, that this system is practicable only when the grades to be surmounted are very slight—a condition rarely found on city tramways. Thus in Paris, our basis of study, this mode of traction would be inefficient on most of the lines.

For the sake, however, of completing our investigation and of harmonizing our examination of the different systems proposed, we shall continue to base our calculations on the example used in the case of the motor car, that is the vehicle in use by the General Omnibus Company of Paris, holding 50 persons; and we shall adopt the figures and coefficients given in our preliminary note, page 321.

(I) We shall assume that the tractive force hitherto estimated at 10 kilograms per ton moved, increases at the rate of one kilogram per millimeter of grade per meter. This increase is nothing but the force which, on a grade, pulls back a given weight, and which is equal to the component parallel to the direction of motion of such weight; this component $= p \sin. \alpha$, p being the weight considered, and α the angle of the direction of motion with the horizon.

(J) We shall admit, in regard to the electric locomotive, that the coefficient of adhesion under average conditions is $\frac{1}{10}$. In damp weather it may be less than this, but may be increased, when necessary, by the judicious use of sand and the employment of brushes to clean the track.

Estimating the weight of the car, with its passengers, at 7,000 kilograms (see C, page 321) we may ascertain the weight of a locomotive capable, as to wheel-friction, of drawing this car. In Paris, grades are found up to and even exceeding 55 millimeters (5½ per cent.). These must be taken into consideration, however exceptional they may be; and so must the curves in a route, where traction is heavy, as well as the question of bad weather.

To draw a car weighing 7,000 kilograms, on a 5½ per cent. grade, there will be required a tractive force of:

$$e = 7{,}000 (.01 + .055) = 455 \text{ kilograms.} \quad (I)$$

Added to this 455 kilograms, the locomotive must have weight enough for its own traction:

$$e' = y (.01 + .055),$$

y being the weight of the locomotive in kilograms.

So that for drawing the locomotive and the car we need a force of

$$E = e + e' = 445 + y (.01 + .055.)$$

And in order that the adhesion of the locomotive exercising this force shall be sufficient, we state the equation,

$$455 + y (.01 + .055) = .1 y.$$

in which 455 is weight needed to draw car, y is weight of locomotive, .055 is the sinus of the angle of the direction of motion with the horizon, and .1 y is the adhesion of the locomotive (J). This adhesion is exactly expressed thus: .1 y cos. x; in which y cos. x is the component of weight of locomotive perpendicular to the direction of motion; but in railroads the cos. x is usually neglected, since it is always so near the level as not seriously to affect the results. In the present case cos. x = .9985, and may be rejected.

Resolving the above equation, from which may be obtained the weight of locomotive required, we find that it reaches the prohibitory figures,

$$y = 13{,}000 \text{ kilograms.}$$

In such a case the cost per car kilometer would manifestly be ruinous, while the cost of road bed, as well as the difficulty of making stops with an engine of such weight, are all added reasons for the failure of any mechanical system of locomotive traction in the streets of Paris. In early experiments, a hopeless dilemma had to be faced; either the locomotive must be too heavy to be manageable, or it must be too light to do its work.

But the case of lighter grades may be considered, and will, perhaps, be of use to other systems than the Parisian. Take, for instance, the case in which grades do not exceed 3 per cent.

The tractive force needed for the car alone would be

$$7{,}000 (.01 \times .03) = 280 \text{ kilograms. (I).}$$

The weight of locomotive, substituting .03 for .055 in our previous equation, is found in the equation

$$280 + y (.01 + .03) = .1y; \text{ and } y = 4{,}667.$$

Let us now, as in the case of the motor car, ascertain the weight of accumulators needed, whether one, two or three groups per car per day be used.

Since the locomotive must weigh 4,667 kilograms, and of this 1,200 may be allowed for car-body, motor, machinery, etc.; we have, say, 3,467 left for weight of batteries. If the batteries required exceed this weight, the excess must be added to the weight to be moved; and if they are less than this 3,467 kilograms, the deficit must be made up in ballast of some kind, preferably by adding to the batteries, thus lessening the labor of the changes at the station, as well as the ampère output.

First. *Traction by means of a locomotive making the 100 kilometers daily with but one group of accumulators.*—In the case of the motor car (page 321), the single group was found to weigh 7,500 kilograms. This weight must now be even greater, (since there is the locomotive in addition to the car to be propelled), and it largely exceeds the 3,467 kilograms allotted to accumulators. The equation is (see H, p. 321),

$$[11{,}667 + (x - 3{,}467)] .005 \times L = x,$$

in which 11,667 is the weight of car and locomotive, .005 is the gross weight of accumulators needed per kilometer kilogram, x is the gross weight of batteries, and x — 3,467 is the weight over and above the 11,667 that must be moved, while L is the distance, 100 kilometers. Whence,

$$x = 8{,}200 \text{ kilograms.}$$

This is prohibitive; for when there is added to it the car, 7,000, and the locomotive, 1,200, the total reaches the enormous weight of 16,400 kilograms. Furthermore, the allowance of 1,200 for the locomotive would be too small if its load of batteries were so great.

Second. *Traction by means of a locomotive using two groups per day, each for 50 kilometers.*

Since the weight of batteries will now be less than 3,467, it may easily be ascertained from formula H (page 321), now stated thus:

$11{,}667 \times 50 \times .005 = x$; so that $x = 2{,}916.75$ kilograms, gross weight of batteries in each group. This involves 550.25 kilograms of extra ballast as explained above. This ballast being needed, the idea occurs of placing a platform for passengers on the locomotive; but, besides its practical objections, it is evident that this form of ballast would be too uncertain to be trusted.

Third. *With three groups of batteries per locomotive per day*, the weight of each group is $11{,}667 \times .005 \times 33{,}333 = 1{,}944.5$ kilograms.

Fourth. *With four groups*, it is $11{,}667 \times .005 \times 25 = 1{,}458.375$ kilograms. And so forth.

But the total weight of all the groups is always $11{,}667 \times .005 \times 100 = 5833.5$ kilograms. For $2916.75 \times 2 = 1944.5 \times 3 = 1458.375 \times 4 = 5833.5$. It cannot be otherwise, since the reduced weight of each group does not now reduce the total weight to be moved; this is brought, in each case, to the 7000 + 1200 + 3467 required. So also the total distance remains constant at 100 kilometers. It is not true, therefore, as it is in the case of the motor car, that with diminished weight of batteries there is diminution of required tractive force, and of all the expenses involved by it.

So that in this case, one group being rejected, the next hypothesis, of two groups, must of necessity be the cheapest; for a greater number simply increases the expense in various items, and does not decrease it in any.

First. *Traction with one group.* This case has been seen to be impracticable.

Second. *With two groups.*

The gross weight of each group is 2,916.75 kilograms. The net weight of the plates in each group is 2,041.725 kilograms.

Number of cars. Twenty-five, as before.

Number of locomotives. The same---twenty in service and five in reserve.

Weight of accumulators. Per locomotive, $2{,}916.75 \times 2 = 5{,}833.50$ kilograms.

For 20 locomotives $5{,}833.50 \times 20 =$	116,670 kilograms.
15 per cent. in reserve	17,500 "
Total gross weight of batteries =	134,170 "

Weight of plates, $2{,}041.725 \times 2 = 4{,}083.45$ per locomotive.

$4{,}083.45 \times 20 =$	81,669 kilograms
15 per cent. in reserve =	12,250 "
Total weight of plates =	93,919

Charging the batteries.---From (F) page 321, we find that each kilogram of the plates requires, in charging, a force of 11,425 kilogrammeters; therefore for 81,669 kilograms of plates there will be needed per day $11{,}425 \times 81{,}669 = 933{,}068{,}325$ kilogrammeters. Say 3,456 h. p. hours, or about 224 h. p. during 15 hours.

We may now establish the price per car-kilometer. This will include the items given, a to m, page 321.

a. Salaries in station less those charged to motive force. The figures given under motor cars, with two groups, were 42,600 fr.; but we have now 17 per cent. more plates to be attended to. For this we add two laborers, each at 1,800 fr., making a total of 46,200 fr.

b. Twenty-one car-drivers, of which one is for emergencies, 63,000 francs.

c. Motive power.—There are 3,456 horse power hours per day, which we shall estimate at 0.085 francs each, this liberally covering interest, wear and tear to motors and boilers, salaries and all repairs, maintenance, oil, etc. Per day, $3{,}456 \times 0.085 = 293.76$ francs; per annum, $293.76 \times 365 = 107{,}222.40$ francs.

d. Interest on battery capital.—We have 93,919 kilograms of plates, at a cost, including construction, boxes, insulators, acids, etc., etc., of 1.25 francs per kilogram; $93{,}919 \times 1.25 = 117{,}398.75$ francs: interest at 6 per cent. = 7,043.90 francs.

e. Repairs to accumulators, boxes, insulators, acids, etc., and change of plates may be put at 0.30 francs per annum per kilogram of plates.

$$93{,}919 \times 0.30 = 28{,}175.70 \text{ francs.}$$

f. Loss of Plates.—The plates in service cost .85 francs per kilogram; $81{,}669 \times .85 = 69{,}418.65$ francs. Renewed twice a year, there will be an expense of

$69{,}418.65 \times 2 =$	138,837.30 francs.
From which must be deducted the price of the old plates, say at 0.20 francs per kilogram: $81{,}669 \times 2 \times 0.20 =$	32,667.60
Leaving annually	106,169.70

g. Interest on capital; locomotives.—Each locomotive will cost about 4,000 francs, including cost of motor, mechanisms, car body, etc., and also the slight alterations needed in the cars now used. The capital required is therefore 25 × 4,000 = 100,000 francs; at six per cent. = 6,000 francs per annum.

h. Repairs to locomotives.—At, say 500 fr. each per annum = 12,500 fr.

i. Deterioration in locomotives.—This will be rapid. Estimating it at 20 per cent., it will equal 20,000 fr. per annum.

j. Oil, waste, small details in the locomotives.—At three fr. per day we have 3 × 20 × 365 = 21,900 fr. per annum.

k. Maintenance and repairs of tools may be placed at 6,000 fr. per annum.

l. Interest, deterioration and repairs of the charging dynamos, transmitters, belts, etc. Taking the capital at 35,800 fr., and allowing 25 per cent. to cover all, we have an annual charge of 8,950 fr.

m. Various charges, 10,000 fr.

Recapitulation for a line of 20 cars of 50 seats each, using electrical locomotives and two groups of batteries for running each 50 kilometers per day; annual expenses:

	Francs
a. Salaries at station	46,200
b. Drivers	63,000
c. Motor power	107,222.40
d. Interest (batteries)	7,043.90
e. Repairs to batteries	28,175.70
f. Deterioration in plates	106,169 70
g. Interest, locomotives	6,000
h. Repairs, "	12,500
i. Abatement "	20,000
j. Oils, waste, "	21,900
k. Maintenance and renewal of tools in the station and on locomotives	6,000
l. Interest, deterioration. repairs on dynamos, transmitters, belts, etc.	8,950
m. Various items	10,000
Total for traction	443,161.70

The annual number of kilometers traversed by all the cars of such a line being (100 × 20 × 365 =) 730,000, the cost of traction per car per kilometer is .607 francs.

Before passing to the hypothesis of three groups of accumulators, we may state approximately the capital necessary for installing battery traction with two daily groups of storage batteries per locomotive.

	Francs.
Engines and boilers, 224.h. p. at 750 francs	168,000.00
Dynamos for charging, transmitters, etc.	35,800.00
Fitting up station, construction, etc.	18,000.00
Storage batteries	117,398.75
Locomotives	100,000.00
Tools, etc.	6,000.00
Extras	26,801.25
Total	472,000.00

Or $\frac{472000}{20}$ = 23,600 francs per car in service.

This sum might be slightly increased by the additional roofage needed for the locomotives.

THIRD. *For the case of three or more groups per locomotive per day,* we can only repeat that the expenses will be greater. Thus the cost of *a, g, h, i, j, k, m,* given above, would be increased by the additional changes of batteries, as well as the greater number of locomotives therefore required; while *b, c, d, e, f, l,* would remain the same. It is therefore useless to examine these cases.

The least cost per car per kilometer on a line having no grades above 3 per cent, and using the electrical locomotive, is thus .607 fr. If the grades are heavier, so must be the locomotive; and the cost increases. If the grades are lighter, so may be the locomotive, and the cost is correspondingly lessened. But this cost, even in the most favorable cases, must remain greater than with the motor car; simply because the additional weight of the locomotive truck causes an addition to the weight of batteries needed. The extra truck must always weigh more than the provisions made to fit the car for accumulators.

FOURTH. *Conclusions as to the electric locomotive.* On lines having grades of 5½ per cent. and over, as in Paris, the electric locomotive is impracticable. On those having a maximum grade of 3 per cent., the cost per car-kilometer is .607 fr., which is 20 per cent. more than the cost of the motor car, ascertained (*ante*) to be .507 fr. Accordingly, in spite of its advantages, the locomotive seems less desirable than the motor car on all roads except those having extremely light grades, or having peculiar conditions rendering its use advisable in spite of its greater cost.

Board of Electrical Control.

The tiresome and apparently interminable wrangle between the Department of Public Works and the Subway company was continued before the Board of Electrical Control on the 19th. Commissioner Gilroy reminded the board of the fact that Broadway is about to be repaved from Bowling Green to Thirty-second street, and that although two months ago the board ordered the laying of a subsidiary duct on the west side of Broadway for the accommodation of property owners who wished to connect with electric light circuits, there are no indications whatever of any intention on the part of the Subway company to construct this duct. Mr. Gilroy said he wanted to know whether the repaving of the street was to be delayed to suit the pleasure of the Subway company or not.

MR. RIDGWAY, State Emigration Commissioner, replied on behalf of the Subway Company, that in point of fact the present delay arose out of a desire on the part of the company to meet the views of the Commissioner of Public Works. The materials provided for the Broadway duct had been used for the laying of subways in Spring street, Madison avenue and other streets, the necessity for attending to which the Public Works Department had represented as being urgent.

MAYOR GRANT: Mr. Commissioner, you had better go right ahead and lay your pavements wherever you decide to have them. When you are ready to pave notify these subway people. If they are ready to go ahead with their work, all well and good; if not, don't wait for them. If this is done and they are not ready, I shall propose in this Board that their permits be revoked. There certainly does not appear to be anything of a drive lately.

MR. GILROY said that after the subways were built and the streets paved, there was actually no security against the latter being dug up again by the subway people. He suggested that the Board should compel the company to make connections to the curb every fifty feet along Broadway, and stated that the expense of this would fall on the electric light companies and not on the Subway company.

MR. KEARNEY, the engineer of the Board, protested against this as palpably unfair to the electric light companies. He said, "By this you propose to impose on these people a hardship that the water department, the gas companies, and everyone else is exempt from."

MR. GILROY: Two wrongs don't make a right. There is a bill now about to receive the signature of the Governor, which will give one the power to make connection to the curb from the water mains whenever streets are being paved.

MR. KEARNEY: It should be done in this case when it is done with everyone else.

MR. GILROY: It has got to be done anyhow. I say this: If the people of this city expect to get good pavements when there is a body here that can tear them up just as they please, they will be disappointed, that's all.

MR. KEARNEY was of the opinion that the pavement would be put back just as good as it was before.

MR. GILROY retorted that Mr. Kearney, if that was really his opinion, knew nothing about street pavements.

MR. KEARNEY said that Mr. Towle, the engineer of the Department of Public Works, had told him that in all probability it could be done. To this MR. GILROY replied that Mr. Towle had given a written opinion to the contrary fifty times.

The dialogue was interrupted by the Mayor, who moved that the engineer of the Board should at the next meeting recommend some system of making connection with the subways without the necessity of tearing up the pavements being entailed.

The revised applications of the United States, Brush and other companies were referred to the expert and the engineer for report.

MR. GILROY pressed the matter of proceeding with the repaving of Broadway, which, he said, was imperatively needed. He was authorized to go ahead with the work forthwith, and was further apprised that the Board would give him its support, and revoke the existing permits of the subway company if they were not prepared to get right down to work and to push on their ducts in advance of the repaving.

The Board adjourned *sine die.*

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-177 TIMES BUILDING, NEW YORK, May 24, 1890.

The Charles Munson Belting Company, who recently opened an office and house in New York, have taken handsome and well-appointed quarters at 44 Dey street, carrying a full and complete stock of their productions.

The Hall Signal Company, of this city, manufacturers of the well-known automatic electric railway signal, have just established an office at 340 The Rookery, Chicago, in order to keep pace with the Western demand for this reliable device.

The Connecticut Motor Company, of Plantsville, Conn., has just concluded arrangements with Messrs. Zimdars & Hunt, wiring contractors, at 127 Fifth avenue, New York, whereby they will sell and exhibit its motors. All interested are invited to call.

H. E. & C. Baxter, 18 Fulton street, Brooklyn, have issued an exceedingly well illustrated 100-page catalogue. This firm manufacturs annunciators, electric bells, burglar alarms, and many other electrical specialties, and gives particular attention to manufacturing these and motors from models.

The Hall Steam Pump Company, 19 Liberty street, have issued a new catalogue of almost 50 pages, which they have profusely illustrated with cuts of their pumps and air compressors. On the last page of the pamphlet is a collection of very useful facts. This company manufacture steam pumps of all kinds for all purposes, and are doing an excellent trade.

Mr. A. A. McCreary announces the incorporation of the McCreary Electrical Specialty company, which succeeds him in the manufacture and sale of patented electrical specialties. In addition to his well known reflectors and half shades, Mr. McCreary has acquired the sole control of several valuable electrical patents to which he will shortly call public attention.

The Vassar Burglar Alarm Company, 56 Warren street, are pushing along the sale of their mechanical burglar alarm clocks. These clocks sound the alarm at the point of attack while yet the door remains closed and fastened. They have a number of testimonials speaking of the efficacy of their alarms, and giving instances in which had it not been that the house was supplied with these instruments burglars would undoubtedly have forced their way in.

Mr. Edward. R. Knowles, general expert, has associated himself with Mr. Ernest C. Webb, counselor-at-law and solicitor of patents, at 181 Broadway. Mr. Knowles will transact a general engineering and expert business, making a specialty of all kinds of electrical work. He will also give attention to the experting of patent cases, and the construction and testing of electrical machines and devices.

The Hine Eliminator Company recently received the following communination from the Lekeis & Collins lumbering establishment, at Norfolk, Va.; "The six-inch vertical eliminator put in here is doing so much better than was expected, that I cannot refrain from writing to you and expressing the satisfaction that we are receiving from its operation. W. W. ROBERTSON, Superintendent and Engineer."

The National Conduit Manufacturing Company, *Times* building, James P. McQuaide, manager, are meeting with much success in the sale of their specialties. One hundred thousand feet of conduit is to be placed by them in Boston; and large orders have been taken for Washington, Philadelphia, Chicago and other large cities. The company have just settled themselves in their new offices, and are ready to welcome their friends and customers.

The National Electrical Manufacturing Company, as successor to the electrical department of the New Haven Clock company, has secured a large factory, 280 by 40 feet, facing the railroad at Milford, Conn. The company will take possession June 1, placing in the new building all the electrical machinery acquired from the New Haven clock Company, and also a good deal of new plant. The New York office is at Nos. 14 and 16 Vesey street.

The Joseph Dixon Crucible Company, of Jersey City, with New York salesroom at 68 Reade street, are extensively advertising Dixon's traction belt dressing and leather preservative. They claim that the proper application of this dressing completely obviates the possibility of the belt slipping. One pound of this dressing, they say, should put in order 81 square feet of leather belting. They make liberal discounts for large purchases in cans or barrels.

The Underwood Manufacturing Company, of Tolland, Conn., have isued a little brochure of 40 pages, gotten up in an exceedingly neat style, and containing much valuable information concerning the cotton leather belting of which they are the sole manufacturers, wood split pulleys, the American system of rope transmission, steel belt lacing, standard belt fastener, etc Mr. O. H. Merrill is their selling agent, and is located at 73 and 74 Cortlandt street, New York city.

An Old Suit Renewed.—The case of Walter K. Freeman against the United States Electric Lighting company has come to trial before Judge Ingraham, of the U. S. Supreme Court. It will be remembered that Freeman claims to have invented a lamp antedating the Edison incandescent. He sues the United States company on the ground that it neglected to push this lamp through the Patent Office, where Freeman's application was rejected. Had he got his patent the company agreed to buy it for $100,000.

Curtis & Dean, who have been for four years agents in New York city and vicinity for the Thomson-Houston company, have opened a new department devoted entirely to isolated electric lighting. Handsome quarters have been taken directly adjoining the large office of the company, where samples will be kept of all kinds of goods belonging to this special branch of the business. Mr. C. R. Dean is the manager of the new department, and he says that the sales that have been made in this vicinity are in every sense satisfactory.

The Goodyear Vulcanite Company have bought out the plant, business and goodwill of the Sonneborn Rubber Comb and Novelty company, and are now located in their new and handsome offices at 353 Broadway. All kinds of goods that are made in hard rubber will be manfactured by them and sold at the lowest prices known to the trade. The new company has just been organized, and but a few days ago elected the following officers: Wm. M. Dean, president: E. E. Sonneborn, treasurer; M. Dittenhoefer, secretary.

The Electric Time Company, for which E. S. Mendels is general agent, is established at 45 Cortlandt street, where it is doing an extensive business in the sale and installation of synchronous and secondary clocks. The company lately issued a neat little folder, in which are presented many testimonials concerning isolated plants installed by it. Among them are the Edison Illuminating company, of Brooklyn; Oxley, Giddings & Enos, of New York, the large electrical fixture makers, and Hanson, Van Winkle & Co., of Newark. N. J.

Leonard & McCoy, 18 Liberty street, New York, carry a full line of wood pulleys, hangers, shafting, rubber and leather belting, electric light and power and steam plant supplies of every kind Wood pulleys should be among the first things thought of by persons equipping electric or steam plants, as they can be driven by less power than the ordinary iron pulleys, and without the danger of being affected by centrifugal force. The new power transmission catalogue of this firm contains much information that is valuable to machinists, engineers and manufacturers.

Mr. A. L. Daniels, of the Eureka Tempered Copper company, of northeastern Pennsylvania, whose New York offices are at 35 Broadway, was about town last week. Mr. Daniels had with him some specimens of his material that had exhibited a tensile strength of 64,480 pounds to the square inch. This copper is made especially for use on dynamos and motors, and Mr. Daniels is now supplying many manufacturers in Philadelphia and elsewhere. The tensile strength of the copper does not detract from its conductivity, and it is said to be excellent for trolley wire.

Mr. G. L. Wiley, general manager of the New York office of the Standard Underground Cable company, has but just taken possession of his new offices in the *Times* building. The carpenters, cabinet-makers, plasterers and furniture and carpet men have been occupying his new quarters for a month past, but have now left him very pleasantly situated. Mr. Wiley was out of town for several days recently, securing a few 50-mile orders for wire and cable, and now feels that he can sit down and enjoy that pipe of his with the pleasure that is always the result of good work well done.

The Electric Company Exonerated.—The inquest in the case of Peter Clausen, an employé of the Northern New York Electric Lighting company, who was fatally shocked on Dec. 10 while repairing a wire at One Hundred and Fifty-Sixth street and Third avenue, has been concluded by Coroner Levy. It was shown by witnesses that the company did not turn on its current until 4 P. M., and that when linemen had occasion to repair a wire after that hour they were directed to notify the company to turn off the current. This Clausen failed to do. The jury exonerated the company from all blame.

The Magnolia Anti-Friction Metal Company, 74 Cortlandt street, have secured one of the best of experts to superintend the production of their specialty. They recently engaged Mr. H. G. Torrey, of the United States mint, to make a test of Magnolia metal for journal bearings. The metal successfully endured a rubbing surface of 2,083 feet per minute, with a weight of 1,200 pounds. It is said that this result is higher and more satisfactory than that of any other test ever made on this or any other metal. When it is remembered that hot journal bearings in dynamos, motors and high-speed engines as well as in general machinery, means the deterioration of the shaft and the ruin of the journal, and sometimes the destruction of a costly armature in a dynamo or motor, the value of a metal that will give such service as the above test indicates is very apparent.

Damper Regulators were never in greater demand by electric light and power steam plants than they are at present. Engineers generally have come to see the need of a good regulator, since it saves steam and facilitates the successful working of a plant. The Hoffman damper regulator, which is sold by F. B. Aspinwall, 112 Liberty street, is having a steady sale. Some of these regulators have recently been sent to Mexico and South America, as well as to various points in the United States. One has just been supplied to the Charlotte Electric Light company at Charlotte, N. C. A Lyman & Warren 10-inch exhaust head and a 400 h. p. Wainwright feed-water heater are being put up for the Easton, Pa., electric light company, and a 150 h. p. heater for the Edison company of Fort Worth, Tex., both by Mr. Aspinwall. He has placed more than 2,000 h. p. value in heaters in the past month.

Simplex Wires and Cables have withstood some of the severest tests to which such material is subjected. W. H. Gordon & Co., 115 Broadway, are constanty filling large orders for these goods, especially to electric railway companies for use as feeders. Particular attention is given to the manufacture of the Simplex wire for this, as well as for mining and underground use, extra heavy caoutchouc insulation being used. Recent sales have been made to companies who are running wires through trees, where it is necessary to have an insulation that will resist abrasion and be free from capillary attraction, as well as possess water-proof and weather-proof qualities. The general supply and specialty business of this firm is first-class. They are pushing the sale of the new telephone wire, which they guarantee absolutely free from induction. Any one who is about to construct a line will do well to examine this firm's stock.

The American Electric Motor Company, 14 and 16 Morris street, Jersey City, occupy a fine large airy room about 50 × 10

feet, well lighted by windows on every side. They have lately brought out their improved type of motor, of which they are selling a large number for running graphophones. Many improvements have been made in the motor, which is coupled to the shaft with their automatic regulator. Both motor and regulator are set on the same base, and the graphophone is supported above the motor by four uprights, and run by a round leather belt which is connected with a pulley on the regulator. This combination allows the motor to be set into a new table which has lately been made for the graphophone, so that the latter will be flush with the surface of the table. The new motor field is composed of two rings 4½ inches in diameter, to which six magnets are connected endwise. The armature is composed of four similar magnets with pole pieces at each end. The current is carried from the magnets in the fields to the magnets in the armature, and only 2 volts and 4 ampères are required to run the whole apparatus at a speed of about 300 revolutions per minute. The company are at work on a new regulator, and will shortly put this and their motor on the market for general use. W. T. H.

NEW ENGLAND NOTES.

Branch Office of The Electrical World,
Room 8, Cook Building, cor. Franklin and Congress Sts.
Boston, May 24, 1890.

A New Trolley.—Mr. J. F. Harriman, at the office of Alex. K. Brown, 82 Water street, Boston, has a trolley which has some new and unique features.

The Johnston Electric Train Signal Company has decided to locate its plant at Woburn, Mass., very favorable inducements having been offered them.

Mr. Geo. W. Mansfield, of the Thomson Houston Company, gave an interesting and instructive lecture on "Electricity" before the Y. M. C. A., of Gloucester, Mass., last week.

The Standard Thermometer Company, of Peabody, Mass., are building extensive additions to their factory. They have large orders on hand for their telemeters.

The Bay State Motor Company, of Peabody, Mass., has received the contract for equipping the Essex street railroad that is to run between Peabody and Salem, Mass. The double trolley system will be used.

The Wainwright Manufacturing Company, of Massachusetts, placed notices through their works, May 1, giving their men the afternoon of Saturday of each week as a holiday, without loss of pay, until Oct. 1.

West End Notes.—The West End Railway company has at its shops, all ready to be put into service, a new motor car. The feature of the car is its size. It will seat from 40 to 45 persons, as against 22 by the old style of car.

Messrs. S. L. Holt & Bart, of Boston, have been awarded the contract for furnishing the steam power plant for the electric railway between Augusta and Gardiner, Me., consisting of two 100 h. p. Porter automatic engines, two 100 h. p. boilers, steam pumps, clutch pulleys, belting, etc.

The New England Electric Company have secured the contract for equipping the Manet street railway, which runs from Quincy to Houghs Neck, 3¼ miles, with the Sprague system. This company sold last week a 10 h. p. and a 15 h. p. Sprague motor to Boston parties, and a number of smaller ones to other parties in New England.

The Massachusetts Electrical Engineering Company, Stone & Webster, managers, are very busy. The position this company occupies in regard to electrical matters is similar to that occupied by the architect to the design and erection of buildings. The advantages to the purchaser of unprejudiced and competent advice in the selection of apparatus is apparent.

The Armington & Sims Engine Company, of Providence, R. I., are working their 275 men on full time and three evenings a week. They say they never had so many orders on hand nor so much business in view. They have increased their plant so that they can now average a 120 h. p. engine per day. They have lately made some special 800-revolution engines for the torpedo service.

A Remarkable Test was recently made at the Consolidated Electric factory of the "H. G." key socket. The test consisted of attaching lamp after lamp of 90 volts to a 90-volt circuit. Twenty-six lamps were safely put on, but the twenty-seventh lamp burnt out the socket. Considering that they were made for use of only ½ ampère each, and were doing good work at 15 ampères, the record is excellent indeed.

The Holtzer-Cabot Electric Company, Boston, have just issued a very complete catalogue of the goods handled by them. It contains illustrations of electrical supplies of all kinds, including all the best motors, wires, etc., full directions for the setting up and use of gas-lighting apparatus, wire and wire gauge tables, battery material directions, and full information regarding their hotel call system. It is an excellent little publication, and we are glad to mention it.

Mr. Levi Cofren, representing Pittingell, Andrews & Co., of Boston, has recently closed contracts with the following companies for large lots of wire and supplies: Worcester Electric Light company, Worcester, Mass.; Lowell Electric Light corporation, Lowell, Mass.; Nashua Electric Light company, Nashua, N. H; Bellows Falls Electric Light company, Bellows Falls, Vt., and Middlebury Electric Light company, Middlebury, Vt. Mr. Cofren has an extensive acquaintance among the trade in New England and the different states and territories, and is liable to be heard from frequently.

Three Electric Railway Companies.—One electric street railroad is being constructed through the streets of Newton, Mass., another has been organized and will come before the aldermen next Monday for a location between Newtonville and Newton Centre, and now a third has been organized with a capital of $40,000, and will also apply for a location somewhat similar to that desired by the Newton Centre road. The name of the new corporation is Garden City Electric Street Railway company. A storage battery system will be used. Col. Hewins, of the Union Car company, of Boston, is one of the stockholders.

Lynn, Mass.—Prof. Thomson, of the Thomson-Houston company, has recently patented an invention which applies the principles of electric welding to soldering and cementing. By this process the parts are put together and properly shielded, the electric current is applied, and the parts fused together under pressure.—Lieut. Cahoon, superintendent of the expert department, has designed a detachable trolley, which, when it strikes a frog, will drop off. It is attached to a chain and can be immediately replaced The device has been successfully operated on the West End road, and twelve more will immediately be ordered.

Newport, R. I.—The Providence Telephone company are having considerable trouble putting up poles and wires in Newport. Last week after a number of poles had been set, and fire alarm and telephone wires strung on them, several property owners hired a gang of men and had the poles and wires cut down. This action is the all-absorbing topic at the present time. Superintendent White, of the Providence Telephone Company, telephoned to this city Friday that he should advise his board of directors to withdraw their system from Newport altogether. The chief engineer of the Newport Fire Department has been to the City Solicitor for instructions, saying that he had absolute proof of the person who cut the fire alarm wires Saturday night, and that they were cut in the road between the sidewalks in front of a vacant lot, the owner of which had entered no complaint against the poles. The City Solicitor said "Do nothing," and the end is not yet.

A Delightful Trip.—The programme announced at the banquet given by the Boston Electric Club to their guests, the Association of Electrical Engineers, was duly carried out on Thursday last. At 9 A. M. the association assembled at the Massachusetts Institute of Technology, and the courtesies of the institution were extended to them by Professor Chase. After an hour of delightful strolling through the well arranged laboratories, of which many a complimentary word was said, carriages, furnished by the West End railway, were taken to the central power house on Harrison avenue. Here the visitors were given every facility to examine the different devices in use, and also to see the work on the new power house, which is being rapidly completed. The drawings of the new buildings were explained at length by Chief Engineer Pearson, after which carriages were again taken to the Park square station, where Superintendent Dumoulin had three "electrics" in waiting, which conveyed the party to Chestnut Hill reservoir, a distance of five miles. The return trip, as well as the outward, was made without accident or delay, and the party arrived at the Parker House at about 12:30. Here an elaborate lunch awaited them, and a vote of thanks was unanimously tendered to the West End Railway and its representatives, Messrs. Pearson and Dumoulin, for their many courtesies. At 1.30 the party departed for the Boston, Revere Beach and Lynn depot, where a special car in waiting in charge of Mr. G. W. Mansfield and Mr. Roher, of the Thomson-Houston company, transported them to Lynn, at which depot 'busses conveyed them to the Thomson-Houston factories. Here an interesting two hours were spent in admiring the beautiful plant, and especially the new system of electric machine. At 4.15, after three cheers for Professor Thomson, who, by the way, accompanied the party on the Boston trip, the party departed for Boston well pleased with their excursion, and voting Boston the only proper place in the world to hold a convention of the kind. Their Eastern friends hope to see them again soon, and hearts and hands will always be open to greet the American Association of Electrical Engineers. L. H. H.

PHILADELPHIA NOTES.

Branch Office of the Electrical World,
31 City Trust Building, Philadelphia, May 24, 1890.

Mr. W. H. Beatty, traveling salesman for the Novelty Electric company, 50 North Fourth street, has packed his grip and started to "do" the big trade of the country. He has many specialties that are well worth seeing.

The White Dental Association, at Twelfth and Chestnut streets, is adding some new electrical specialties to an already excellent line of goods Large quantities of platinum are handled by the Association, and the electrical trade is supplied at the lowest-market rates.

Friction Clutch Pulleys have become almost a necessity to large electric light and power plants. Moore & White, of Philadelphia, who are always doing something of this kind, have recently brought out one of these pulleys, which is being adopted by some of the largest plants in the country.

J. Elliot Shaw & Co., 53 North Seventh street, are among the oldest manufacturers of household electric specialties, and were early in appreciating the advantages of utilizing Norway iron in electric work. They have long been established at their present address, where their reputation has been made, and where they produce a fine line of general goods.

W. S. Griffith & Co., 114 S. Fifteenth street, electrical engineers and contractors for the installation of electric light, power and railway plants, are agents for the Mather system. In the basement of their building they have installed a very pretty isolated station. It is composed of two 500-light dynamos, run by two automatic high speed engines. They furnish the light for the Colonnade hotel, as well as for several other buildings and a number of offices. They have recently added 200 lights to their 100-light plant in the Genesee Salt Works at Piffard, N. Y.

Dr. Otto Flemming, 1,009 Arch street, is one of the oldest manufacturers of electro-medical specialties in this section of the country, and is said to be the most original in his line. Some time ago he brought out a very unique novelty—an electric ozone machine. The machine is in a compact form, is operated by a small battery, and is inclosed in a handsome wooden case, the whole small enough to be conveniently carried; it is particularly adapted to purifying the air of a sick room, and is meeting with an excellent demand. The medical batteries and cautery apparatus of Dr. Flemming are of the best, and satisfaction is the general result of their use.

American Measuring Instruments.—Philadelphia has the reputation, with some, of being rather slow and conservative, but Queen & Co. have apparently outgrown their surroundings. Until within the last two or three years practically all the measuring apparatus used in this country was imported from abroad, a popular feeling existing that the value of an instrument was enhanced if a foreign name appeared on it. We are glad to say that such is not now the case. Queen & Co. have demonstrated that they can make electrical test instruments equal in quality to those of foreign make, and as reasonable in price. They are finding customers for their standard resistance boxes, portable testing sets, ammeters and voltmeters and their other specialties in all parts of the United States, and have even had inquiries from abroad. They report a recent large sale in the Northwest, comprising Ayrton & Perry instruments, portable testing sets, Cardew voltmeters, tachometers, etc., to the amount of about $1,500. We are informed that a new and enlarged edition of their catalogue I-66 is now in the printers' hands.

WESTERN NOTES.

Branch Office of The Electrical World,
465 The Rookery, Chicago, May 24, 1890.

Mr. C. A. Schieren, of New York, was one of the prominent belt manufacturers attending the convention at the Auditorium hotel last week.

Mr. C. A. Ross, of Kansas City, has closed a contract with parties at Trenton, Mo., for a 30-light arc and a 650-light 16 c. p. incandescent machine of the Thomson-Houston system.

Mr. E. L. Burrell, the Western representive of C. A. Schieren & Co., has secured orders from the Joliet Street Railway company for a 26-inch perforated electric belt, and for two 12-inch electric belts.

Minneapolis, Minn.—The complete Edison electrical exhibit, as made at the Paris exposition, has been secured for the Minneapolis exposition. Strauss' Vienna orchestra will furnish music.

Mr. J. W. Slossons, Chicago, the general agent of the Denver & Rio Grande Railway company, has kindly presented this office with a framed photographic view of the grand scenery in the valley of the Gunnison, through which their line runs.

W. P. Adams & Co., with offices in the Electric Club building, Chicago, have secured the contract for supplying two 200 h. p. McIntosh & Seymour engines to the Chicago Edison company, and have also closed contracts for three engines of the smaller capacity.

The Walsh Gasoline Torch Manufacturing Company, 48 West Adams street, Chicago, are making a blow-pipe and blast torch that is of special value to electricians, owing to the fact that the flame is drawn to a long fine point, and that the apparatus can be carried in the pocket.

C. B. Holmes. J. J. Mitchell, W. B. Walker and C. Buckingham, Chicago capitalists, controlling nearly all the street car lines in Davenport, Rock Island and Moline, are in Davenport, Ia., considering the question of a new motive power. At the annual election of the syndicate, C. B. Holmes was chosen president and E. A. Holmes secretary.

The Sale of the Property of the Kalamazoo Street Railway company under a mortgage for nearly $110,000 held by the Central Trust Company, of New York as trustees, took place at Kalamazoo, Mich., on May 15. J. Greehy, of New York, bid it in for Messrs. Walter Stanton, Wayne Griswold and Thornton Motley, trustees for the stockholders, for $42,550.

Cleveland, O.—The whole city is preparing for the reception of visitors on Memorial Day, when the Garfield monument in Lake View Cemetery will be dedicated. The Brush Electric company and others will close their works on that day. The East Cleveland Railroad company is making efforts to transport the expected crowds, and think it can on that day carry 50,000 people to Lake View.

Mr. H. S. Walker, the Western manager of the Wainwright Manufacturing company, Randolph and Canal streets, Chicago, is having an excellent trade in his line. He has secured many contracts for the installation of the Wainwright feed water heaters and condensers, all of which are sold under a ten-years' guarantee. Mr. Walker is sending out two handsome placards that engineers should not fail to secure.

Electric Railway for Chicago.—South Chicago and the Calumet district are going to have the first electric street railway to be operated in this town. The Calumet Electric Street Railway took out its papers of incorporation on May 16, at Springfield, and will have its tracks down before July 1 The incorporators are N. K. Fairbanks, S. E. Gross. Joel D. Harvey, W. V. Jacobs and Otho S. Gaither The capital stock is $50,000.

The Knapp Electrical Works, 54 and 56 Franklin street, Chicago, are carrying a very complete line of the elegant incandescent shades and globes made by the Phœnix Glass company, and can supply the same at manufacturers' prices. This enables users of this class of goods in the West to secure their goods without delay. A line of plain, roughened, and opal globes for the various styles of arc lamps, is also carried in stock.

Mr. J. M. Duncan, of Chicago, the well known Western representative of the Rice engine, has recently closed some handsome contracts for this reliable engine. A 125 h. p. engine has been placed in the Hamilton works near Fond Du Lac; a complete steam plant, including a 125 h. p. Rice engine, in the electric railway plant at Dubuque; a Rice engine in Sprague, Warner & Co.'s wholesale house, and one to drive the electric light plant at Litchfield, Minn., are among recent installations

The Hazleton Tripod Boiler Company, whose offices are at No. 170 Twenty-second street, Chicago, have issued a circular and a report of the recent sales made by them. The circular, if testimonials count for anything, shows that their boilers have successfully endured severe tests, and are giving general and full satisfaction. Their sales aggregate a large number, and show that the company are doing the prosperous business which usually accompanies the manufacture of a good piece of mechanism.

The Chicago Arcade Rapid Transit Railway Company has been incorporated, to construct a line of road from a point on Fifth avenue, between Madison and Harrison streets, with branches on Milwaukee and North avenues, to the present or future city limits. The principal office will be at Chicago, and the capital stock, $8,000,000. The incorporators and first board of directors are: E. Louis Kuhns, H. A. Ritter, A. F. Shuman, Percy L. Shuman, and Joseph H. Defrees, all of Chicago.

The National Engineering Bureau, 331 The Rookery, Chicago, are making a specialty not only of expert service in the testing of line insulation, the economy of steam plants, etc., but also of furnishing specifications and drawings and information relative to the cost of installing both steam and electric light and power plants. Thus prospective purchasers are able to ascertain from an unbiased and disinterested source a close approximate idea of what a proposed installation may cost.

The Electrical Supply Company, 171 Randolph street, Chicago, have found that the demand which they have created for Habirshaw wires is very large, and Mr Terry goes East this week to arrange for an unusual supply, as at the present rate no ordinary stock of one or two carloads will answer the purpose. As Mr. Terry was successful in laying in an extensive stock of Shield brand and other wires before the last raise in copper, the company is in an excellent shape to fill orders on favorable terms.

The Knapp Electrical Works, 54 and 56 Franklin street, Chicago, have replaced much of the machinery destroyed by the fire, and are now better equipped than ever to handle the ever increasing trade in their needle annunciators, burglar alarms, etc. The entire building is being renovated, and when completed the interior will present a handsome appearance. The company has taken care of all orders sent in, including three for several tons of the magnet wires made by the American Electrical Works. Several hundred coils of Grimshaw wires have just been received, the demand for them being constant.

Telephone Quotations.—Col. S. G. Lynch, broker, 146 La Salle street, Chicago, furnishes quotations on telephone stocks as follows:

Chicago	$293	@$297	Cumberland	$ 59	@ $60
Central Union	73	@ 74	Wisconsin	116	@ 117
Michigan	98	@ 99	Bell of Missouri	140	@ 145
Great Southern	30	@ 32	Iowa Union	21	@ 23
Colorado	38	@ 40	Missouri and Kansas	54	@ 55
Rocky Mountain Bell	40	@ 45			

ELECTRIC LIGHT STOCKS.

Chicago Arc Light and Power	$112	@$115	Chicago Edison Co	$117	@$118

The Sunbeam Incandescent Lamp Company, corner of Randolph and Canal streets, Chicago, are now supplying to the trade an incandescent lamp that is remarkable for the brilliancy of the light afforded, for the entire absence of any discoloration, and for

the comparative long life of the thousands already turned out. They have given such excellent satisfaction as to have won the name of "the high-grade lamp." Only the finest material is used in the construction, and there is nothing cheap about the lamp, not even the price—though the latter is fair and just when the quality and the life of the lamp is considered. Mr. J. H. Cooke, the secretary and treasurer of the company will furnish correct data and testimonials from present users of the lamp to any one desiring them.

The Hall Signal Company, of New York, have opened an office and exhibition room in The Rookery, Chicago, and have a model of their entire system in full operation for inspection by the hundreds of railway officials who daily congregate in The Rookery. The Hall system of block signals, interlocking grade crossing and junction signals, station signals and highway grade crossing signals, are shown almost as they appear on the various roads where now used. Mr. A. W. Hall is in charge of the office, and is ably assisted by Mr. S. M. Young. The exhibition room is one of the brightest and most cosy apartments one is likely to enter, being furnished in excellent taste. Mr. Young says that his company are prepared to supply at their own expense on lease their automatic electric signals to railroad companies at a fixed annual rental for a guaranteed service to be rendered, payment of rental to be dependent upon fulfillment of such guarantees.

The Charles Munson Belting Company, 22-36 Canal street, Chicago, are opening up an excellent trade in South America, where they have a traveling representative who has sent in orders this season for some 1,200 feet of belting. As the majority of belts used in that country are of English manufacture, a high class belt like the Munson sells on sight. Mr. Frank G. Moss, the secretary and treasurer of the company, made an excellent chairman of the committee that entertained the belt manufacturers during their recent visit to this city. After an informal lunch at the Auditorium, the entire party were escorted in eight carriages to South Park, thence to Jackson Park, the prospective site of the World's Fair, and along the boulevards, after which they were afforded a view of the city from the top of the Auditorium, and then the interior of that great building was especially illuminated in honor of the guests, thus affording them every opportunity for seeing the good things in Chicago.

An Excellent Report.—The city electric light plant at Goshen, Ind,, consisting of a Rice automatic engine, 9 × 16, and a Western Electric company's 35 arc light dynamo, was recently tested by the National Engineering Bureau, of Chicago. The following is a synopsis of the report on the test: Lamps, 2,000, nominal c. p. taking 10 ampères and 42.5 volts; internal resistance of dynamo, hot, 24 ohms; resistance of line wire, 15 ohms; power lost, due to line resistance, 2.001 h. p.; friction of engine and dynamo running light, 5.58 h. p.; indicated horse-power with 25 lights, 25.3 h. p. Deducting loss in friction and line resistance, the net power required for 25 lights equals 17.719 h. p., or .71 h. p. per light. The efficiency of the dynamo at this load was found to be 77.4 per cent. In this connection it may be noted that the dynamo is carrying but three-fifths of its normal capacity. The line is about four miles in length, and consists of about one mile of P. & B. and three miles of Underwriters' wire. The insulation resistance measured 1,110,700 ohms. The engine made 258 revolutions per minute, and the difference in speed between no load and 25 h. p. was found to be one revolution.

The Illinois Electric Material Company, Chicago, is the title of a new company organized and incorporated under the State laws to do a general merchandising business in the line of electrical supplies. The officers of the company are active business men, well and favorably known in Chicago and to all the Western members of the fraternity. The general manager and vice-president is Mr. Ernest Hoefer, the genial representative of the Bishop Gutta Percha company, the Trinidad-Heimann Insulated Wire company, and other Eastern corporations. Mr. Ernest L. Clark, the Western representative of the Walworth Manufacturing company, and known to all as "the pole man," owing to his success in securing large contracts for poles, is the secretary, while the president and treasurer is Mr. H. S. Winston, a gentleman of high standing, and a successful operator in real estate circles in Chicago. The company will make a specialty of line construction material, poles, crossarms, insulators, etc., and will carry a stock of sufficient size to warrant them in contracting to supply all the material required in the construction of circuits of any length. The company will do no construction work, and stand on neutral ground respecting all parent companies. They will retain the agency of the Bishop gutta-percha white core wires, the Trinidad-Heimann weather-proof line wire and the Walworth steel and iron poles and brackets for electric railway, power and light circuits. The offices of the company will be located in suite 351 The Rookery, in order to be accessible to every one in the city, as well as to out-of-town buyers. Ample store-rooms for an extensive stock have also been secured.

The American Water-Works Association were in session last week at the Grand Pacific Hotel, Chicago, and on Tuesday Mr. William B. Bull of the Quincy Water Works, who was last year made chairman of a committee on electrical devices for boilers, delivered an interesting report of his experiments. His attention had been called to the apparatus for "ageing" wine by an electro-magnetic current, and he tried the same arrangement to see if he couldn't prevent scale from forming in boilers. After awhile he concluded to drop the electro-magnetic appliances and see what could be done with permanent magnets. So he rigged up an iron cylinder in which he made a series of "grids" of bar steel permanent magnets, through which the water fed to the boilers was made to pass. He found that instead of the mineral impurities of the water adhering to the boiler and the tubes, it formed a soft sludge in the bottom and left the heating surface clean. He tried it on a boiler attached to a lime-burning establishment. The water came from a well sunk near by. It was pure, but it was excessively hard. The scale in that boiler was as hard as Portland cement. The application of the magnetic cylinder caused the hard scale to become as pliable as fresh mortar. The sludge under the microscope showed that it was a mass of irregularly crystallized particles. He had only three months' experimenting with the permanent magnets, but in six months' longer time in which to try its effect on other waters than those containing the carbonate of lime, he believed that another use could be added to the lengthening list of magnetism. Dr. Leeds called attention to the fact that about twenty-five years ago the Franklin Institute had experimented in this direction and had obtained promising results, but that for some reason the promises had not been fulfilled and the matter had been dropped. The plan then in use was to fix permanent magnets in the crown sheet of the boiler, connecting them by wires to the forward sheet. Mr. Bull in reply said that such a method could not be of permanent value, because of the heat to which the magnets had been subjected. "Put the best permanent magnets in a temperature of a high-pressure boiler," he said, "and in twenty-four hours they would be so much scrap iron. I have found that the best way, in fact the only way, to preserve the life of the magnet is to present the water to them, if not cold, at least before it has been heated to near the temperature of that in the boiler." Mr. Bull was continued by unanimous vote on this committee for the next year. F. DE L.

ENGLISH NOTES.

(From our own correspondent.)

LONDON, May 14, 1890.

Electric Omnibuses.—It is announced the Ward Electric Car company will shortly commence to run a line of electric omnibuses between King's Cross and Charing Cross stations. Hitherto the electrical omnibus has only been seen in our streets before dawn or after dusk. As soon as it makes its appearance in broad daylight, we shall see whether the electric omnibus comes under the same law as other vehicles which are propelled along the streets mechanically, and which have to go at a walking pace, preceded by a man with a red flag.

The Edinburgh Exhibition.—On the 1st of May there was opened at Edinburgh an exhibition which promises to be of a very successful character. Electricity forms one of the chief features of the exhibition, and although the electrical exhibits contain little that is novel, the features are both numerous and varied. Perhaps the most striking features of the exhibition are the telpher line and the short electrical railway, and the small fleet of electric launches which convey visitors to the exhibition from the city along the Union Canal. A few exhibits are driven by electric motors, but, strange to say, as a rule, where small-power compact motors are required, gas engines have been made use of.

Maxim Weston Electric Company.—This company, which was formed some years ago to exploit the Maxim-Weston patents in this country, has had thoughout a most unfortunate career. The latest balance sheet discloses the fact that during the past year the sole income of the company amounted to £41 13s., this princely sum having accrued from transfer fees and interest. Under these circumstances it may be imagined that the meeting of shareholders was a somewhat stormy one, and although no formal decision was arrived at, it was practically decided that as soon as the litigation against its late chairman, Mr. Hugh Watt, is concluded, the company will be dissolved.

Co-operative Telephony.—Some few months ago the high rentals at present charged by the National Telephone company and the prospect of the Bell patent expiring in the present year, gave rise in the North to a movement for the adoption of a system of co-operative telephony. The outcome of this movement is the Mutual Telephone company, which has been formed with a capital of £100,000, and which proposes to inaugurate without delay a telephone exchange in Manchester, where promise of considerable support has been received. The annual rental for shareholders is to be £5, and £6 for other renters, an extra charge being made for distances over one mile. It is proposed to use complete metallic circuits and to adopt an improved system of central exchange switching. If the Mutual Telephone company is able to give the public an improved service at a reduced rate its success will be assured; but in the National Telephone company it has a most formidable competitor, with a long purse, considerable experience and present possession; which latter, in telephony enterprise, is even more than the proverbial nine points.

Electric Tanning.—A large party of experts and members of the technical press paid a visit this afternoon to the works of the British Electric Tanning company at Rothsay street, Bermondsey, for the purpose of witnessing the process of tanning by electricity, which has been in operation on a commercial scale since September last. After the peliminary processes of soaking the skins and denuding them of hair, the hides are placed in revolving drums containing the ordinary tanning liquor, with the addition of some turpentine. Through these drums, which are 77 feet 6 inches in diameter, and which revolve at a speed of about eight revolutions per minute, a current of 10 ampères at a pressure of 100 volts is passed. In the ordinary process of tanning, which takes from five to six months, the mixture of acids and gelatine gives rise to an almost impenetrable coating on the exterior of the hides, and it is the formation of this coating that makes the ordinary process of tanning such a lengthy business. What part is actually played by electricity *per se*, is by no means quite clear, but it is supposed that the remarkable way in which the process is reduced, viz.: to five or six days, is due to the ordinary diffusive action of the electric current, superadded to the heat caused by its passage and the pressure of the gases evolved in the hermetically sealed drums. A large quantity of hides tanned by this process was shown, and many tanning experts expressed themselves much astonished at the results. The British Electric Tanning company own the patents of MM. Worms and Balé. A process of electric tanning, in which the hides are hung on a revolving frame, has been devised by M. Groth, but I do not think that this process has as yet been brought into commercial use.

The Wright-Ferranti Meter.—Messrs. Wright and Ferranti have recently made a most beautiful practical application of the principles underlying the remarkable repulsion experiments of Professor Elihu Thomson. Our readers will no doubt remember that one of Professor Thomson's experiments was to cause the rotation of iron or copper pivoted discs placed near to iron or steel bars in which the propagation of magnetism was throttled by closed circuits. This property of a bar made magnetic by a periodic current has been ingeniously applied by Messrs. Wright and Ferranti to the construction of an electric meter. In its latest form the meter consists of a pair of vertical electro-magnets, with divided iron cores. To the poles of this magnet are attached curved horns of laminated iron. These curved horns lie in the same horizontal plane and are magnetically throttled at intervals by copper bands. Inside the space comprised by the horns there is a thin iron or copper band, which forms the periphery of a light wheel capable of rotating on a vertical axis. Geared to this axis is a counting mechanism, and the speed of rotation is retarded by mica vanes. The throttling effect of the iron horns causes the rapidly reversing magnetism to take the form of a lateral diffusion of lines of force from the sides of the horns. The passage of these bunches of lines of force through the metal band, which forms the rim of the movable wheel, generates in it eddy currents. These are continually repelled by the moving field producing them, and hence a motion of rotation is given to the wheel. By suitably proportioning the different parts of the meter, the total number of turns of the wheel in a given time can be made proportional to the total quantity of electricity which flows through the meter. This ingenious device was described by Dr. Fleming at a meeting of the Society of Arts, in the course of a lecture on Prof. Elihu Thomson's experiments. The lecture was of a most interesting character, and was illustrated by a profusion of experiments.

The Lodge Lightning Protector.—The discussion at the Institution of Electrical Engineers on Dr. Lodge's recent paper on his new form of lightning protector, although brief, was of considerable practical interest. The line of argument generally taken by the speakers was that the lightning protectors at present in use are, so far as the post office and submarine cable companies are concerned, quite good enough, inasmuch as the protection afforded by them was practically perfect; so that unless Dr. Lodge was prepared to supply an equally good article at a considerably reduced price, there was no commercial field for his ingenious device. In support of this view, Mr. Saunders, of the Eastern Telegraph company, stated that throughout the 25 years of his experience he had never known a cable or instrument protected by his lightning guard to be damaged. Mr. W. H. Preece told the same tale with regard to the post office. From the post office returns for 1889, it appears that out of 600 valuable instruments, quadruplex, duplex, Wheatstone, etc., not a single one had suffered damage from lightning. This statement was corroborated by Sir Henry Manse and others who had had practical experience of the Saunders lightning guard. Professor Hughes and Mr. Charles Bright pointed out that the principle underlying Dr. Lodge's protector had long been applied, though no doubt without any clear idea of the *raison d' être*. Dr. Lodge in reply said that, though judging from the statements of several speakers ordinary protectors did their work well, they were all open to the objection that they were frequently damaged. Now whenever the protector was damaged, he contended that something else was also damaged, although the injury might not be visible. As to the relative danger to underground and overhead wires, Dr. Lodge pointed out that if the former were entirely underground they would be practically secure, but as such was not the case he thought that the same principle that is used in protecting buildings from fire by means of fireproof doors should be adopted, and the protector should be placed in electric light leads wherever underground wires leave the earth.

Central London Electric Railway Scheme.—The bill promoted for the construction of an underground electrical railway is now undergoing the process usual in this country of a detailed scrutiny before a select committee of the House of Commons. The object of this line is to connect the residential district of Bayswater with the West End and the city, Bayswater at present being dependent solely upon omnibuses. The length of the line will be 4½ miles, and it will run at a depth of 50 feet under the streets, terminating in the city at the bank of England. The capital of the company is £2,500,000. The scheme is to be engineered by Sir John Fowler, Sir Benjamin Baker and Mr. Greathead, and it is proposed to run two iron tubes, 11 feet in diameter, at the above mentioned depth, through the London clay. The passengers are to be taken to and from the trains by means of hydraulic lifts. It is expected that a maximum speed of 25 miles per hour will be attained, the average speed being, however, only 14 miles per hour; but even this will take passengers from Bayswater into the city about three times as quickly as they are at present taken by the omnibuses. There are to be nine stations, at intervals of about half a mile. It is needless to say that a scheme of this novel character has aroused considerable opposition. The sixty odd petitioners against the bill may be broadly divided into those who fear damage to property from vibration, and the owners of sewers, gas, water and electric mains, etc. Among the petitioners are the Dean and Chapter of St. Paul's, who are afraid that cathedral will be brought down The counsel for the bill is of the opinion that "the scheme would have about as much effect on St. Paul's as the tickling of a tortoise's back with a feather." The first witness called in support of the bill was Mr. J. H. Greathead, whose evidence was of an interesting character. He was of opinion that he would be able to pierce the London clay at the rate of 15 feet per day. The weight of the trains which it is proposed to run would be about one-half the weight of the trains at present run on the Inner Circle Railway, that is to say, 80 tons as against 165. He was confident that there would be no damage to property from subsidences and that the cost of working by electricity would not exceed that of working by steam. The trains are to be worked in the same manner as those on the City & Southwark Subway, that is to say, there are to be separate electric locomotives, and the potential will be about 600 volts.

THE TELEGRAPH.

Caro, Mich.—The City Council, it is thought, will advocate the placing of a fire-alarm system in this place.

Boone, N. C.—A company is being organized to build a telegraph line from Boone to Blowing Rock.

Port Chester, N. Y.—The committee on fire department of the Board of Trustees has recommended a fire alarm for the town.

Wilmington, Del.—New bids will probably be solicited for the police telegraph in this place, as the old bids were all returned.

Port Huron, Mich.—The Ways and Means committee of the City Council may be addressed concerning a fire-alarm system that is in contemplation. It is said that $1,500 will be expended on a plant.

The Postal Telegraph Company are to place their wires underground in St. Louis at an expense of $10,000. The system will extend about a mile. It is claimed that the entire change can be accomplished in 8 or 10 weeks.

The Association of Railway Telegraph Superintendents will hold their annual meeting at Niagara Falls on June 18 and 19, and arrangements are being made to have handsome exhibits of telegraph apparatus and supplies.

Commercial Cable Stock.—A London syndicate, composed of parties interested in the Canadian Pacific railway, has purchased a large block of commercial cable stock. The following gentlemen have been elected directors to represent the interest: Sir Donald A. Smith, W. C. Van Horne, and C. R. Hosmer, of Montreal, and Thomas Skinner, of London. More than one-half of the capital stock is still personally owned by Mr. John W. Mackay.

The Monitor District Telegraph Alarm Boxes will be ready for the market June 1. Mr. Armstrong, the patentee, has just perfected a lightning arrester, whereby the wire from each box is grounded. This is an important improvement, as thereby all danger from lightning to the operater is obviated, and the burnout of the boxes prevented, while alarms may be sent during the most violent electrical disturbances of the atmosphere. The Monitor Electric company, under whose auspices the box is being manufactured, is now permanently located at No. 149 Wabash avenue, Chicago, Ill.

An Important Decision.—The Supreme Court of Georgia has recently handed down the following decision in the case of Hill vs. the Western Union Telegraph company. It decides that: 1. When the blank upon which the sender of a telegraphic message writes and signs his name, has printed upon its face the words, "The company will not be liable for damages in any case where the claim is not presented in writing within sixty days after sending the message," he is chargeable with knowledge of and assent to the terms and conditions thus indicated. 2. Such a stipulation is reasonable and therefore obligatory. 3. The agent or manager of the company on duty at the station from which the message was sent, is a proper person upon whom to make demand for damages claimed, and he is competent to recognize and act upon an oral demand and thus waive any writing. Such a waiver will result from his refusal to pay upon the sole ground that the company was not to blame.

THE TELEPHONE.

Jacksonville, Ala.—A telephone exchange will be established here.

Buena Vista & Lexington, Ky.—The telephone line between these points has been completed and is now working satisfactorily.

Prestonsburg, Ky.—The State Legislature has been petitioned for a charter for the Mt. Carbon, Prestonsburg & Pikesville Telephone Line company.

A New Telephone Line.—A telephone line is being constructed between Greenville, S. C., and the town of Greers, and will probably be extended to Chick Springs

The New York and New Jersey Telephone Company has filed in the office of the clerk of Union county, a mortgage on its plant of $1,500,000, given to the Atlantic Trust company.

Bell Telephone Stock.—It is probable that new stock will be issued to take up the $2,000,000 issue of 10‡ year 7 per cent. debenture bonds that were put out Aug. 1, 1888, redeemable Aug. 1, 1890.

Playing Whist by Telephone is said to be one of the recreations indulged in by General Superintendent Hubbard, of the American Telegraph and Telephone Company. Mr. Hubbard can lay claim to the "odd trick," at all events.

Newport, R. I.—It is understood that the Providence Telephone company will stop work upon the reconstruction of its lines here, over which so much opposition has been developed, and will seek compensation from the city for damages already suffered through lack of police protection.

The Bell Telephone Company, of Canada, has concluded a contract for the construction of a double copper telephone line between the Dominion and provincial capitals. The lines will run over Montreal, and when they are completed conversation can be carried on over 250 miles, the longest distance yet attempted in Canada.

Newnan, Ga.—Mr. J. E. Dozier, of the Atlanta office of the Bell Telephone company, was in town recently arranging for the establishment of a local telephone exchange, and for the extension of the Atlanta line from Fairburn to Newnan. Work will begin at once, and both the Atlanta line and the local exchange will be in operation by July 1.

Increase of Capital Stock.—The Providence, R. I., Telephone company has authorized the board of Directors to increase the capital stock by the whole or any part of the additional $100,000 authorized by their charter, as their needs may demand, stipulating that the additional stock first be offered to the stockholders at par in proportion to their respective holdings.

The Telephone in Denmark.—It is reported that the Government of Denmark has erected 50 telephone stations, chiefly on the west coast of Jutland, for the use of fishermen, who are thus able to communicate with fish dealers at a distance, and thereby secure better prices. All the life boat stations in the country are so connected by telegraph and telephone wires.

The Providence, R. I., Telephone Company seems to have much difficulty in extending its lines. Many of the property owners along the route refuse to permit the erection of poles on their premises, and the company has therefore been obliged to put the poles up at unequal distances. The new line presents an odd appearance; at some places the poles are placed so close together that they form what may almost be called a group, while at other places they stand singly with long spaces intervening.

Washington, Pa.—A detective in the employ of the Bell Telephone company paid a visit to this city a few days ago, and while here served notice on a number of business men who had been using private telephones, to surrender the instruments. The telephones in question were put in by Rustin Devore, and the Bell people claim infringements of their patents. The users of the private telephones are not at all anxious to part with the property, but at the same time they fight shy of a conflict with the Bell corporation.

THE ELECTRIC LIGHT.

Blacksburg, S. C.—An electric light plant will be established here.

Sigourney, Ia.—An electric light plant will soon be installed here.

The Sherman, Texas, incandescent company will buy new dynamos.

Aransas Pass, Tex.—An electric light plant is to be erected by J. C. Fulton.

Clinton, N. Y.—The people of this place have voted in favor of lighting by electricity.

Salisbury, N. C.—An electric light plant is to be erected by the Salisbury Gas company.

Fort Collins, Colo.—An electric light plant will soon be established in this place.

Cherokee, Ala.—It is reported that an electric light plant is about to be erected in this place.

The Rock Hill, S. C., Electric Light Company will soon advertise for bids to put in a plant.

Blacksburg, S. C.—An electric light plant will be erected by the local land and improvement company.

Newburg, N. Y.—It is probable that improvements will soon be made to the electric light plant at this place.

New Bedford, Mass.—The Turner Electric Light company has been organized, with a capital stock of $15,000.

New Albany, Ind.—The electric light company is making arrangements to put in an additional 50-light dynamo.

Brunswick, Ga.—An electric light plant will be established by Dunham, Hotchkiss & Co., to light their planing mill.

Moundsville, W. Va.—Actual work, it is said, will soon be begun on the construction of the proposed electric light plant.

Lebanon, Mo.—A franchise to light the town with electricity has been granted to B. F. Hobart, of St. Louis, and associates.

Bristol, Conn.—The electric light company are to enlarge their plant again. A new 120 h. p. engine and boiler will be put in.

Prestonsburg, Ky.—An application for a charter has been made to the Legislature by the Prestonsburg Electric Light company.

Valdosta, Ga.—An electric light plant and ice factory are about to be erected in this place by M. B. Lane and others. Machinery is wanted.

Marion, Va.—Application for right of way has been made to the City Council by an electric light company that has just been organized.

Spartansburg, S. C.—The Spartansburg Mills of this place are being equipped with electric lights. The Thomson-Houston system is used.

Perth Amboy, N. J.—The Raritan Electric Light company has been incorporated at this place. The sum of $75,000 will be expended in a plant.

Athens, Ga.—W. A. Robinson, of the local electric light company, is reported as saying that the company will probably have to increase its plant.

Rochelle, Ill.—The C. C. Hinckley Manufacturing company has entered into negotiations for the erection of an electric light plant in this place.

Reno, Nev.—The electric storage lighting plant in the asylum is reported to be giving complete satisfaction. No trouble has yet been experienced with it.

Pensacola, Fla.—It is said that the Pensacola Electric Light and Power company has ordered machinery sufficient to double the capacity of its plant

Johnson City, Tenn.—A. M. Young, of Waterbury, Conn., has bought the electric light plant, and will increase its capacity and move into new quarters.

Altoona, Pa.—The Edison Illuminating company have increased their plant by the addition of a 65-light Brush machine, with its accompanying lamps.

Dublin, Tex.—The franchise to erect the electric light plant mentioned in our last issue has been awarded to A. A. Chapman, R. W. Higginbotham and others.

Asheville, N. C.—L. M. Cox, of Washington, D. C., has been awarded the contract to furnish 60 arc lights of 2,000 c. p. each to light this city, at $5,000 per annum.

Saco, Me, has decided to adopt the Westinghouse alternate current system of electric illumination. The initial plant will consist of one 750-light incandescent dynamo.

The Elmwood (Ill.) City Council are reported to be in the market for an electric light plant. The entire matter is in the hands of C. B. Morey and James Putnam.

The Molden Electric Light Company will furnish all night service for incandescent lighting of dwellings and mercantile houses in Medford, Mass., on and after Sept. 1, 1890.

Milwaukee, Wis.—The Edison Electric Light company is pushing the construction of its plant. It is expected to be in operation by Aug. 1. The wires will be laid underground.

Booneville, Mo.—The Electric Light company has employed Mr. S J. Duncan to superintend the construction of this plant. Mr. Duncan was formerly electrician at the State penitentiary.

Chanute, Kan.—The Westinghouse Electric company has just sold a 750-light dynamo, which will be used toward dispelling in a measure the darkness which nightly gathers round the town.

Lakeland, Fla.—The equipment for the Tampa Bay hotel includes 2,000 incandescent lights. The contract has been awarded to Mr. C. Z. Suthern, of New York, and work has already begun.

New Haven, Conn.—The aldermen have ordered the city lamp committee to investigate the advisability of changing the 1,800 c. p. lamps now in use, for a larger number of 1,200 c. p. lamps.

Macon, Ga.—At a meeting of the Home Electric Railway company held a short time ago, the following directors were elected: A. C. Knapp, W. E. Jenkins, Peter Harris, W. A. Doody and D. J. Baer.

The Fairmont, W. Va., Electric Light Company has let to the United Edison Manufacturing company, of New York city, the contract for the erection of the electric light plant lately mentioned.

Canton, O.—The Common Council has awarded to the Canton Electric Light and Power company a contract for 40 arc lights to burn all night and every night, at $100 a year: also 70 arc lights at $70 per year.

Waxahachie, Tex.—A meeting of the electric light company was held yesterday afternoon, and a committee was appointed and given instructions to arrange for work to begin at once in putting up the electric light plant.

Falls of Presumpscot, Me.—The electric light plant is nearing completion. Eleven turbine wheels of 150 h. p. capacity each are being installed. It is expected that all will be finished and ready for business by the 1st of July.

The Fort Dearborn Light and Power Company, of Chicago, has been incorporated to buy and operate electric machinery, etc. The capital stock is $25,000. The incorporators are: A. L. Baker, E. F. Runyon and S. T. Parks.

Baltimore, Md.—Owing to the rapid increase in the business of the Brush company, that organization has found it necessary to increase the capacity of its incandescent plant by the addition of a Westinghouse 3,000 light alternate current dynamo.

The Electric Light and Power Company, of Aurora, Ill., has received its new 750-light Westinghouse dynamo, and expects a 35-arc light Thomson-Houston dynamo to arrive soon. Commercial business had necessitated this addition to the plant.

Manchester, N. H., now has three electric light companies, a new one having recently been granted a franchise by the city government. The new company has a capital of $20,000, and has organized under the voluntary corporation laws of the state.

Roanoke, Va.—The Roanoke Power company, with a minimum capital stock of $50,000, has been organized, and will furnish electric light and power. R. L. Garner is president, J. F. Christian vice president, and L. S. Simmons secretary and treasurer.

The Old German Catholic Cathedral at Strasbourg, is now lighted by electricity. Arc lights have been used outside with excellent effect, and it is stated that many of the noble lines of the architecture are now accentuated by night as they never have been by day.

Copenhagen, Can.—The city, which owns the principal gas works, has decided to establish an electric lighting station to supply the central part of the town. The station will have a capacity of 10,000 incandescent lamps, and will be so arranged as to permit enlarging.

Los Angeles, Cal.—The electric light company recently changed management. W. B. Cline is president; W. R. Blackman, secretary; Jas. Warren, superintendent. The company will put in a 1,500-light incandescent plant, new boilers, etc., at a cost of about $15,000.

The Elizabeth City, N. C., Electric Light Company is nearly ready for service. The new engine and boilers are in position, and two new dynamos have been received. Mr. J. R. Coomes, Jr., on expert electrician, has been selected by the company as superintendent.

Oshkosh, Wis.—A reward of $100 has been offered for the apprehension of some one who has been tampering with the electric light wires. Electric light wires are by no means the safest things in the world to fool with, and the meddler may some day be caught by the electric current.

The Westinghouse Incandescent Lamp is to be employed at the far-famed Bar Harbor on the coast of Maine. The Westinghouse Electric company has just closed an order with Bar Harbor people for 2,250 capacity in generating apparatus of the alternate current incandescent type.

The Parkersburg, W. Va., Electric Light & Power Company says that its franchise runs for a considerable period yet, and that the service which the company has given the city has been entirely satisfactory. And there is no indication that the city intends to undertake its own lighting.

The Electric Light for Divers.—Electric lighting has been found very useful in diving operations connected with sunken vessels. The wires are run directly from the poles of the dynamo and are wound around the air-tube, sufficient slack being left for handling the lamp without choking off the air supply.

Batavia, N. Y.—The Consumers' Electric Light and Power company, and the Batavia Gas Light company, both of this place, have been merged into the Consolidated Gas and Electric company. The capital stock is $100,000; S. D. Purdy is president, and Henry Craft vice-president. Charles H. Caldwell is secretary and treasurer.

Braddock, Pa.—The Citizens' Electric Light company has been obliged to increase the capacity of its incandescent lighting plant. A contract was made with the Westinghouse Electric company a few days ago, to furnish a 750-light alternate current dynamo. This addition will give the company a total capacity of 1,400 lights.

Fredonia, N. Y.—The people of this place are determined to have electric light. The old contract with the gas company, which has expired, will not be renewed, and it is proposed to invest in an electric light plant. A petition will be sent to the Legislature asking the privilege of issuing bonds to the amount of $10,000, in order that the plant may be built.

Swampscott, Mass.—The committee appointed to mark the location in the various streets where the proposed new arc lights are to be placed, have finished their work, and voted to adopt the Thomson-Houston system. A contract has been awarded to the Lynn Company for 75 arc lamps of 1,200 c. p. capacity. The new line will be finished by Aug. 1.

Elizabeth, Pa.—The recently incorporated Elizabeth Electric Light company, which intends to illuminate the thriving town of Elizabeth, situated on the Monongahela river, a short distance from Pittsburgh, has purchased ground on which to place its station, and has let the contract for the machinery. It is the intention to have the plant in running order very soon.

Connersville, Ind., is to have the electric light. An electric light company recently organized at that place has just closed negotiations with the Westinghouse Electric company for a 750-light incandescent dynamo, and two 40-light arc dynamos, all machines to be of the alternate current type. United States Treasurer, Mr. J. W. Huston, is the president of the Connersville company.

Montgomery, Ala.—The Citizens' Electric Light and Power company will install a Ball plant. The following gentlemen have been chosen directors: H. T. Beggs, F. Lilienthal, C. G. Abercrombie, H. C. Davidson, P. B. Bibb, Alex. Rice and W. H. Gesner. The following officers were elected: P. B. Bibb, president; H. Davidson, vice-president, and W. H. Gesner, secretary.

Terre Haute, Ind.—A new 50-light arc dynamo for commercial business has been added to the plant of the local electric light company. They contemplate, also, an addition to their building, and will probably put in dynamos for 3,000 incandescent lights. The people of the place are so appreciative of the electric light that the demands upon the company's business compel the above extensions.

The Wilmington City Electric Company, of Wilmington, Del., has for some time been contemplating extensive improvements in its electric light plant, to meet the great increase of patronage on the part of the citizens of that city. The company has just contracted for a new 740 light machine, Westinghouse alternate current incandescent system, and no time will be lost in the installation.

Boonville, Mo.—The contracts for the necessary electric light machinery for the plant of the local electric light and power company have been awarded. The arc dynamo will be furnished by the Sperry Arc Light company, of Chicago, and the incandescent dynamo by the National Incandescent Electric Light company, of Michigan. It is expected that the plant will be in operation by July 1.

Portsmouth, N. H.—The Portsmouth Gas and Electric Light company are loaded to their utmost with Thomson-Houston arc and incandescent machinery. They will extend their station and make additions. The station is a most excellent one, and was designed by Mr. Fred S. Palmer, who has now accepted a position with the Bar Harbor, Me., Electric Light company. Mr. Palmer is well spoken of by all.

A novel use of the Electric Light is made on the St. Lawrence river near the Thousand Island resorts. One of the lights has been placed at the end of a yard-arm on the steamer "St. Lawrence," which has a dynamo aboard. The light stands in front of a powerful reflector; and as the boat steams about at night among the islands the search-light is cast upon them, revealing with startling distinctness their beauty and the beauty of the landscape.

Bedford City, Va.—The Bedford Electric company has in use a 50-light Schuyler arc dynamo and two 360-light Edison dynamos. Thirty of their arc lights are in use for street, and 20 for commercial lighting. They have 1,000 incandescents wired on the two Edison machines. The same company is about to commence the construction of a four mile electric street railway. Bedford City is a progressive town of nearly 4,000 inhabitants and is growing rapidly.

Omaha, Neb.—The Thomson-Houston Electric Light company has introduced a day circuit which will furnish light and power. They are soon to have a 200-h. p. engine, to take the place of the 45-h. p. engine doing the work at present. New wires have been placed about the city, and many arc lights will be put in dark basements where gas is now used. In addition to this, some 1,000 incandescent lights will be run, besides furnishing power for printing presses, elevators, etc.

Creston, Ia.—The electric companies are making things lively on the streets of Creston, these days. The blue and red poles of the Gas Electric company, and the white poles of the Water Works Electric company, make an exceedingly singular and variegated, if not patriotic appearance. The Gas company is putting in a first class Westinghouse combined arc and incandescent lamp, and Ragan and Vaughn of the Water Works company are also putting in an electric plant.

Electric Light for Aiming Guns.—Experiments have lately been carried on at Toulon with a view of determining to what extent accuracy of aim could be attained at night with the use of electric light. A gun was mounted on a revolving platform, which also carried an electric projector. The target was fired at a distance of between three and four kilometers, and it was found that the same accuracy could be obtained under these conditions as during daylight.

Veazie, Me.—A number of exceedingly annoying delays have occurred to retard the work of erecting the electric lihgt plant at

this place. It is now, however, well under way. $1,000,000 is to be used in constructing and furnishing the brick building, which will be 250 feet long and supplied with electrical machines of the most recent patterns. Power will be supplied from this point to run electric cars to Bangor, and it is expected they will be running in side of a month.

Novel Plan for Street Lighting.—One of the Paris compressed air distributing companies has been awarded a contract for street lighting on a novel plan. The company distributes power through its condensed air system to a vast number of small dynamos, each of which furnishes current for a small number of lamps. The electricity thus generated is free from danger and the lighting is perfect. The system has, moreover, the admirable recommendation of extreme cheapness.

The Value of Perfect Joints.—Professor Jamieson, in a recent lecture, devoted some time to the necessity of the most rigid care being exercised in the jointing of electric light conductors. He says: "Unless the joints are thoroughly well-made, and equal in insulation resistance to at least the same length of the cable or branch leads, leakage or even serious fault may occur at them. Electric light contractors would do well to take a lesson from the rigid but necessary system of perfect jointing."

Veazie, Me.—The plant of the Bangor Electric Light and Power Co., at this place, when finished, will be one of the largest electric stations in New England. The foundations are at present nearly completed, and consist of more than 2,000 cubic yards of masonry. The entire length of the building will be 242 feet and the width 75. Six large water wheels are to be put in at once, each of 100 h. p. In addition there will be an auxiliary steam power. Half a million feet of lumber will be used in the construction of the building.

Toronto, Ont.—Since the establishment of the Ball Electric Light company in this city, in 1882, it has been necessary to enlarge its premises no less than five times, owing to the steady increase of business. Now it has moved from Adelaide street to Pell street, where it will have four times the amount of space it has hitherto enjoyed. A molding shop has been established which will supply all castings for the company. It is this evidence of prosperity, among others, that is productive of the confidence and good will of the public, and it is the more pleasant to note on this account.

St. Louis, Mo.—The electric light has entirely superseded gas in this city. The Metropolitan Electric Light and Power company has a contract with the city for ten years, and the work of extending the system so as to take in all the streets will be vigorously continued. The new plant went into operation on the first of May, and has proved entirely satisfactory. There are now 1,613 arc lights in operation on the streets of St. Louis, and there are 492 miles of Simplex wire strung. The longest circuit is 18 miles and has 57 lamps on it. There are 39 dynamos each of 60 lights capacity. The Wood lamp is used.

Raleigh, N. C.—A dispute has been going on for some time past concerning the efficiency of the electric lights furnished the city by the Raleigh Electric Light company. The difference has been settled by arbitration. The lights were offered as 1,200 c. p., but proved on investigation to be only 775 c. p. The rate of payment was $80 per year on a 1,200 candle power basis. Now the city will pay $51 66 per lamp from the time the system went into operation. There are 59 lamps, and the annual reduction is $1,388.33. The lamps burn all night and every night. The light company announces its intention to bring the light up to the contract basis.

The Suburban Light and Power Company has filed in the office of the clerk of the Supreme Court another petition, asking for a writ of mandamus to compel the Board of Aldermen, of Boston, to grant the petitioner a writing or writings, specifying where in the highways and public roads of Boston, especially in South Boston, West Roxbury, Roxbury, and the Dorchester districts, the petitioner may erect such a number of posts as shall be reasonably necessary and proper to enable it to perform its various contracts with the city. The petition is substantially the same as the one filed some weeks ago by the company, and contains the same general allegations, except that it is now alleged that the petitioner, on March 3, 1890, presented to the Board of Aldermen its request for a location of posts. A hearing will probably be given at an early date.

Cincinnati, O.—It can now be said with absolute certainty that the Cincinnati Electric Light company, which is virtually the Cincinnati Gas company, has absorbed the local Brush electric lighting company, and the business of the latter is now conducted entirely by the former. It is rumored that the decision rendered by Judge Kumler in the recent war among the local electric light companies, will hamper the Jones Brothers and Queen City companies, as the decision virtually prohibits them from running their wires on poles in the street. But even if the decision is sustained by the higher courts, it will not in any way prevent these companies from continuing to supply their patrons with light, as it does not prohibit them from running their wires over house tops. The public may feel at ease on this score, as these companies have established a good business, are up to the times, and are fully prepared to protect their interests.

A New Station Controller has been invented and patented by W. H. Elkins, formerly of Boston, but now of New York, which will be a great boon to the consumer. He has also perfected a standard regulator for the company. The operation is as follows: In a circuit of arc lights, a number are to be put out at seven o'clock, a number at nine o'clock and the balance at twelve o'clock. At seven the operator turns the switch or key socket twice; this throws waves of current into the device, and these waves of current set in motion a small upright pendant which, when it reaches a certain point, automatically throws the cut-out into position, thus cutting out the light. This operation is continued through resistance coils for the later hours, a larger amount of ampères being thrown for each hour. If a merchant who usually burns a light until 9 o'clock wishes to burn it later, he may notify the lamp renewer when he is around in the day time, and he can immediately set it for 12 o'clock; then that light cannot be turned off until the amount of current used in turning the 12 o'clock lights is forced through to the cut out. A syndicate has been formed to manufacture the "controller," and it will, no doubt, meet with a ready and rapid sale.

APPLICATIONS OF POWER.

Johnson City, Tenn.—An electrical steel railway is to be built.

Detroit, Mich.—The Shawhan Motor company has been organized with a capital of $2,000,000.

Norfolk, Va.—It is reported that C. G. Waller & Co. will put a 10-h. p. Baxter electric motor in their shoe factory.

San Francisco, Cal.—The California Electric Transit company will establish a plant here. Address M. Livingston for details.

Lowell, Mass.—The Thomson-Houston company has the contract for a 10 h. p. motor, which will be used in the city carpenter shop.

Plymouth, Mass.—Another street railway may be established in this place. There is considerable agitation on the subject.

Bangor, Me.—Important extensions are to be made to the plant of the local electric street railway. Several additional miles of track will be laid.

Rockford, Ill.—It is said that the electric railway will soon be in operation—probably within 90 days. The necessary bonus of $10,000 has been subscribed.

Augusta, Ga.—The contract for the erection of the electric power house of the Augusta Railway Company has been awarded to Messrs. Brown and Starlings.

Altoona, Pa.—The Street Railway company are making preparations to substitute electricity for the mule. The Thomson-Houston system will probably be used.

The First Alternating Current Motor in Italy has just been started. The machine is of 5 h. p., and is running at Alzano Maggiore. It is used to drive a centrifugal pump.

Peoria, Ill.—It is proposed to use the Pennock electric system on the street railroads. Theoretically the system is a success, and if it proves so in actual practice the dynamo is doomed.

Savanna, Ill.—The Savanna, Ill., Street Railway company has been organized with a capital stock of $50,000. The incorporators are, William P. Rhode, C. K. Miles, and F. S. Greenleaf.

Omaha, Neb.—The street railway company in this place is a lively and progressive institution. It employs 400 men, operates 40 miles of electric road, and contemplates building 10 miles more this summer.

St. Paul, Minn.—The local authorities of Streator, Ill., have recently closed a contract with W. S. Morton, of St. Paul, for the construction of eight miles of electric street railway. The cost is to be $200,000.

Jay Gould and Cyrus Field, it is said, are endeavoring to operate a scheme for connecting near Long Island towns with Brooklyn, by extending the electric railroad which connects East New York and Jamaica.

The Detroit Storage Battery, which was purchased by a Chicago syndicate, has been tested, and has given very satisfactory results. The battery will, perhaps, be given a further test on the West Side street railway.

Birmingham, Ala.—The stockholders of the Birmingham Railway and Electric company will hold a meeting on June 10, to consider the issuing of $2,500,000 of negotiable bonds and securing same by mortgage of deed of trust.

Port Townsend, Cal.—The Belt Line Electric Railway Company has been organized, with a capital stock of $150,000. The trustees are James McIntyre, B. S. Pettygrave, August Duddenhausen, John Gagen and H. W. Keppes.

Columbus, O.—The Glenwood and Green Lawn Street Railroad has been reincorporated, the purpose being to convert it into an electric road. The new system is to be in operation as soon as possible. B. S. Brown, one of the stockholders, can furnish information.

The Nonotuck Silk Company generates power from a water wheel at its lowest mill in Leeds, Mass., then turns it into electricity, conveys it to the new mill thirty rods above, where it is converted into motion by means of a dynamo, and thus it does the work of a 65-h. p. engine.

Union, Ore.—The local electric light company has begun operation, with a 600-light Edison plant. The same company has under construction three miles of electric railroad, connecting this town with the Union Pacific Railway. The Thomson-Houston system is used to furnish power for the railroad.

Salem, Mass.—The Naumkeag Street Railway Company is hurrying along the work of laying its track and of putting in the ground wire for the electric overhead system. By the terms of the permit granted to this company, all its divisions in Salem must be completed and ready for operation in July.

Minneapolis, Minn.—Estimates are now being made by engineers for the construction of a large electric power plant on Meeker Island. If the plant is installed, power will be furnished to the electric street railway line and to other enterprises. It is said that Henry Villard is largely interested in this scheme.

Roanoke, Va.—The Roanoke Power company has been incorporated, to erect a plant to supply power and light to industries, private individuals or the city. The capital stock will not be more than $50,000 nor more than $250,000. R. L. Garner is president, J. F. Christian, vice-president, and L. H. Simmons, secretary and treasurer.

One Hundred Miles of Street Railway in the city of St. Louis will soon be operated by electricity. The city has granted franchises to new companies, and has also granted permission to old companies to change their horse railroads to electric railways. The work of altering some of these lines is now in progress, and there are seven systems either using electric power or preparing for its immediate introduction.

Lansing, the Capital of Michigan, is to have a model electric street railway, built by the Westinghouse Electric Railway company. The Westinghouse people have a national reputation for their ability in perfecting everything that they undertake, and in street railway work they guarantee that every road will be a model to which prospective builders can confidently refer. The road will be pushed to completion at once.

New Bedford, Mass.—At a meeting of the Board of Aldermen on Friday last, the petition of the Union Street Railway company for right to erect poles and run wires on certain streets, for the purpose of operating part of its road by electricity, was granted with several conditions, one of which was that the company erect iron poles such as are used in Boston for the trolley system. There has been considerable opposition to the granting of the petition.

Tarentum, Pa.—A charter was granted at Harrisburg last week to the Tarentum Traction Passenger Railway company; capital $50,000. The directors are: John C. Grier, of Punxsutawney; David O. Hutchinson, of Pittsburg; Worthy A. Dumbrill, of Allegheny City; Samuel Lauck, of Driftwood; Charles E. Shoop, of Franklin, and John M. Morrison, of Logan's Ferry. It is a foregone conclusion that electricity will furnish the motive power for this proposed street car line.

Wilmington, Del.—An iron drawbridge over the Christiana River is about to go into service, operated by electricity. The draw is 250 feet long and 34 feet wide, with a roadway and two footways. The total weight is about 200 tons. The motor is furnished by the Thomson-Houston Company, and at a recent test turned the draw completely around in 1½ minutes. The bridge is lighted with 14 incandescent lights from the same current that supplies the motor. The total cost, including the motor, was $65,000.

A Dispatch from Buffalo conveys the information that the syndicate headed by H. Sellers McKee, of Pittsburgh, has just completed negotiations for the control of the entire street railway system of Buffalo, N. Y., by the purchase of all existing street railways in that city. Recently franchises for a new system of railways in Buffalo were acquired by this syndicate, so that it will now have entire control of the Buffalo street car lines. A good deal of money is involved in this deal, $3,000,000 being the figure named.

Newton, Mass.—The railroad commissioners have refused to grant a permit to the new street railway corporation to cross the tracks of the Boston & Albany Railroad. The corporation has organized under the general laws, and expects thereby to secure a crossing. All of the required capital stock, $20,000, has been subscribed. Another company has petitioned the city council for permission to operate the storage battery system, and desires the same location as the first company. The city council is about to act upon the petition.

Augusta, Ga.—The railroad committee of the City Council have granted the privileges of additional streets to the Kansas City Electric Railway company, and have also given the old street car company the right to use electricity on its lines. Augusta is known as the "Fountain City," having taken its name from an old fountain that was built on Broad street a quarter of a century ago. The other day this old landmark was removed to make room for the track of the new electric railway. It is now proposed that the city pseudonym be changed to that of "Electric City."

Macon, Ga.—Representatives of the Progress Land, Loan and Improvement company recently visited Mr. George F. Work, of Philadelphia, who owns extensive electrical railway properties in Macon, and asked him to the price for which he would sell. It is reported that he placed the figure at $275,000. This caused an immediate stampede on the part of the committee. Mr. Work gave $75,000 for the street railway about a year ago, since which time he has converted it into an electrical road at a cost of about $25,000. This, with his other property, is said to have cost him about $150,000.

Electricity for Fire Engines.—One of the Boston fire commissioners declares that electricity will soon take the place of steam in fire engines. He said: "The question of getting an engine of the greatest water-throwing capacity to the fire with the greatest celerity will, it seems to me, be solved by electricity. Substitute for the steam power of any modern engine, stored electricity, or electric power conveyed to each hydrant, making of your engine a pump on wheels, and you have lightness itself as regards weight, with almost unlimited power of throwing water. This will be the fire engine of the future."

Winterthur, Germany.—Several large manufacturers are occupied with the electrical power transmission from the cataract of the Rhine to Winterthur. A large volume of water is to be withdrawn from the Rhine above the cataract, which, when conducted to Winterthur with 75 per cent. of useful effect, will there still yield 1,500 h. p. It is not intended at first to make the enterprise available for manufacturers generally, as the power transmitted will be sufficient for only a few factories. The accomplishment of the project will be of great importance to the principal industries of Winterthur, which are engineering and metal founding.

A Large Purchase.—The street railway syndicate, composed of H. Sellers McKee, of Pittsburgh, Murray Verner, of Buffalo, and E. H. Clark, of Drexel, Morgan & Co.'s Philadelphia banking house, is said to have bought the entire street car lines of Louisville, Ky., paying $1,200,000 for them. The street railways of Louisville are antique in the extreme, and with the exception of those in the downtown streets, are operated on the switch system. The Broadway and Sixth avenue lines have been great money-makers, and the prosperity of the latter dates back to the establishment of the exposition at its terminus. Several years since the lines all over the city were consolidated, and the equipment was somewhat improved, but rapid transit was apparently unthought of until Messrs. McKee and Verner took in the situation and its possibilities. Negotiations were begun a few weeks ago and the transfer was made a short time afterward. The company in Louisville will be reorganized and a reconstruction of the entire system will be inaugurated. Electricity will be the motive power on all the lines.

PERSONALS.

Mr. George Westinghouse, Jr., of Pittsburgh, was among the guests at the Auditorium, Chicago, last week.

Mr. W. J. Phelps, formerly of Elmwood, Ill., is now on the staff of Mr. Alexander Kempt, the Western manager of the Brush Electric company.

George E. Honners has been appointed manager of the New England Telegraph and Telephone company's offices in Gloucester, Mass., vice Geo. O. Stacey, resigned.

H. E. Roberts, formerly manager of the Boston office of the New England Telephone and Telegraph company, has accepted the position of district manager for the Southern New England Telephone company, with headquarters in Bridgeport, Conn.

Col. C. M. Ransom, treasurer of *Modern Light and Heat*, we regret to say, is a very sick man. At this writing it is impossible to know what the result will be. The Colonel has a host of friends among the electrical fraternity throughout the country, who trust that his illness may prove only temporary, and that soon his genial and pleasant smile may be with us again.

Mr. John C. Miles, one of the brightest passenger men in America, now New England agent of the Boston and Maine Railroad, will in all probability be tendered the general passenger agency of the above company on the promotion of Mr. Dana G. Flanders to the traffic managership. Mr. Miles has many friends throughout the country who will sincerely wish him much success.

Drowned at Portsmouth.—Miss Rand, employed as telegraph operator at Newburyport, was drowned while in company with her brother on the way, in a small rowboat, to Newcastle, to attend the funeral of an uncle. When opposite the navy yard the boat was struck by a squall, and both occupants were thrown into the water. Willing hands immediately manned boats and pulled to the rescue, but both had sunk before help could arrive.

John W. Roloson, who died in Brooklyn on the afternoon of May 22, was one of the most expert telegraphers in the United States, and was well known in electrical circles, where he was universally respected. Mr. Roloson had long been an enthusiastic bicyclist, and on the Saturday previous to his death, while riding his machine on a Brooklyn street, was knocked down by a passing truck and received internal injuries that resulted in death from peritonitis. He had held important positions in Western Union offices in New York, and was at the time of his untimely end night manager of the Postal Telegraph company. He was a widower, only 31 years old, and leaves two sons, aged seven and four years, respectively.

MISCELLANEOUS NOTES.

Electric Transfer Tables are among the modern features of extensive railway switch yards

Interesting Data.—In the United States the telephone is used 595 times, and the telegraph 136 times a minute.

The Rockford, Ill., Electric Manufacturing Company has filed a certificate of increase of capital stock to $100,000.

The Erie Telegraph and Telephone Company, Boston, made an increase of 109 subscribers during the month of April.

Grinding Drugs by Electricity.—An electric apparatus for grinding drugs in drug stores has been devised, and is meeting with much favor among the members of the trade in England.

Austin, Tex.—The citizens have decided by vote to erect a granite dam 60 feet high across the Colorado river. The cost will be $1,500,000, and it is expected that 14,000 h. p. will be thus obtained.

The Sacramento, Cal., Electric Construction Company has been incorporated by W. Gambs, W. B. Lazard, G. W. Daywalt, W. R. Lott and W. B. Reynolds. The capital stock is $1,000,000.

Middleton, Ohio.—The warehouse and workshop of the Hobart Electric company have been destroyed by fire. The loss is $4,100; insurance, $200, on building only. The origin is said to be incendiary.

New Code of Naval Signals.—At the Charlestown, Mass., navy yard, the officers are practicing daily on a new code of signals, founded on the Morse alphabet, and intended for use in signaling between ships at sea.

San Francisco, Cal.—The Electrical Engineering company has been organized. The directors are: C. E. Green, C. B. Sessions, E. J. McCutchen, Sidney B. Cushing and D. L. Bishop. The capital stock is $1,000,000, divided into 50,000 shares.

San Francisco, Cal.—The Electric Vapor Engine company has been incorporated by Irvine Steuart, Frank E. Temper, John W. Eisenhuth, Robert F. Young and W. H. C. Fowler. The capital stock is $100,000, of which $50,000 has been subscribed.

Diamonds by Electricity.—A further step toward the artificial production of the diamond has been made by passing an electric current through carbon electrodes in a cell containing a fine white sand and electrodes, the whole being under considerable pressure.

Another Large Belt.—The Brush Electric company, of Minneapolis, Minn., have had a large belt made in Chicago. The belt is 126 feet long, 68 inches wide and weighs 600 pounds. It is cemented, no rivets having been used, and was submitted to 250 tons hydraulic pressure.

Riveting by Electricity has been successfully accomplished. The cold rivet is placed in the hole, and when heated to the proper temperature is closed by any of the ordinary apparatus now in use. The heating of a half-inch rivet of two or three inches in length takes about half a minute.

A Bright Boy.—An Athens, Ga., fourteen-year-old boy has made a complete dynamo capable of lighting one large arc light, run by a treadle. He has also made a complete telephone, with an improvement in the transmitter which is said by electricians to work perfectly, and to be much simpler than the one now in use.

The Phonograph in the Class-Room.—Edison's phonograph has found a new application at the Milwaukee College, where it will be used as an assistant in teaching the French and other foreign languages. In giving a lesson the teacher reads it before the phonograph, and the lesson is reproduced whenever wanted.

Los Angeles, Cal.—The Rhodes and Keese Electric company has been incorporated. Col. G. Wiley Wells, J. P. Colby, S. J. Keese, T. H. Rhodes and W. I. Keese constitute the board of directors. E. F. Spence, B. W. Lee, F. Sabichi and G. T. Kernighan are stockholders. The capital stock is $25,000, of which $15,000 is subscribed.

Providence, R. I.—The factory recently owned by the Goodyear Rubber company is being prepared for the occupancy of the Denison Electrical Manufacturing company, which will start up in a week or so. The Denison company was incorporated a short time since for the manufacture of electrical supplies, insulated cables and wires. Mr. Russell A. Denison is president.

A New Incandescent Lamp has been brought into the market, which, it is stated, will obviate discoloration. The carbon filaments are made of raw silk threads put through a careful process, and capable of bearing high temperatures. A suspended needle is fitted inside from the socket to the glass tip, and prevents the shaking and attracting of particles of carbon to it.

Hartford, Conn.—A factory for the manufacture of electrical insulators is to be erected by the Johns-Pratt company, and a second building has also been begun. The main structure will be a two-story brick building, 140 feet long and 40 feet wide. The smaller building will be of brick, 90 feet long, 40 feet wide and three stories high. There will also be an engine and boiler house.

The St. Louis Electrical Exhibit.—The electrical exhibit, in connection with the St. Louis exposition this year, promises to be the most complete ever seen in this or any other country; not that the efforts made by the Mound City to achieve success are more strenuous than those made for other exhibitions, but that even a few months of electrical development expose many new scientific facts and possibilities.

Pittsburgh, Pa.—The Chief of the Department of Public Safety has made up his mind to enforce the ordinance relative to the injury of shrubs and trees. He will proceed against employes of telephone, telegraph and electric light companies found guilty of defacing trees and shrubs while stretching wires along the streets. The penalty is a fine of fifty dollars, and the arresting officer is to receive half of the amount.

An Illustration.—"The danger of an ignorant person in seizing an electric wire carrying a strong current, is as great as that to which a person ignorant of the ways of snakes would be subjected if he undertook to take the place of the skilled observer, accustomed to put his arm into a tall jar containing rattlesnakes and take them out," is Professor John Trowbridge's graphic illustration of one source of danger connected with electric wires.

Sale of Telegraph and Telephone Shares.—Some 3,000 shares of the West India Telegraph and Telephone company, owned by the Tropical American company, have been sold for $2,500 cash. The company's 500 shares in the Brazil company will shortly be offered at $10 each, as the company wishes to convert all its holdings into cash. General Manager Howard bids 10 cents for the July and January dividends of the Tropical company.

The Link Belt Machinery Company, of Chicago, Ill., are building a new machine shop. It will be of iron, designed and built by the Berlin Iron Bridge company, of East Berlin, Conn. The building will be 121 ft. wide. The central portion will be 40 ft. wide by 42 ft. high, with a traveling crane running the entire length. The wings will be 40 ft. in width and two stories high. A hydraulic crane will occupy the entire central portion of the building except for a distance of 30 ft. from one end, which will be used for offices.

Westinghouse and Pullman.—It is understood that Mr. George Pullman, the car builder, and Mr. George Westinghouse, Jr., are about to form a company to construct electric street railways on a large scale. The main office will be in Pittsburg, Pa., or Chicago, Ill. It is said that Mr. Westinghouse is now in Chicago settling the details of the combination. A site will be wanted near the works of the Pullman company for the manufacture of motors. Many New York capitalists are said to be interested.

An Advantageous Severance.—The step that has just been taken by the New York Electrical Society of assuming its own responsibilities and its independence of action, will relieve the electrical fraternity and the public on a point that has frequently involved considerable complexity. As the society is no longer the Electrical Section of the American Institute, the confusion that has at times arisen between it and the American Institute of Electrical Engineers is at an end. The society is a progressive body, and has plans for the coming season that will materially enlarge its sphere of usefulness.

Electrical Education in Preparatory Schools.—The Board of Education of Cleveland, O., is discussing whether it will pay to continue the Manual Training School in connection with the public school system. The average graduate has, by superior fitness, already proven the advantage of the technical training over the ordinary high school course; and none more so than those now in electrical pursuits. With the so apparent interest taken by the pupils in constructing electrical apparatus, and the general record of manual training schools as stepping stones to electrical engineering courses at college, it is to be hoped that the electrical workers at Cleveland will use their influence towards enlarging and elevating this practical institution.

Wires Saved His Life.—In Milwaukee, a few days ago, a boy employed in the office of the Northwestern Collection company in attempting to close a window, lost his balance and fell headlong. The window is nearly a hundred feet from the ground, and the people who saw him fall expected to see the boy dashed to pieces on the sidewalk. About twenty feet below the window, however, there is a network of wires, and upon this the boy struck, holding with both hands and swinging in a way that made the spectators dizzy. Next came the fear of death by electric shock; but the boy hung there as unharmed as if clinging to a trapeze in his father's barn. Before the fire department could get their truck, which had been summoned, to the spot, the boy was pulled in to safety through a window below the one from which he had fallen. He was absolutely uninjured, except from natural fright, and ate his dinner with the usual relish and appetite of a boy of fifteen years of age. The deadly wire!

The Spokane Falls Electrical Society, of which a notice appeared in a recent issue of The Electrical World, is one of the indications of the advance which electrical science is making in the far West. Its membership now numbers about thirty, and is mainly composed of the employés of the Edison Electric Illuminating company of the city, but the limits of membership are extended so as to include those belonging to other professions. The society possesses two handsome rooms in the centre of the city, and has already gathered some most interesting electrical appliances, which are on exhibition in the rooms. At its last monthly meeting the members had the pleasure of listening to a lecture by Mr. R. J. Fleming, assistant dynamo engineer of the Edison Company, on "The Principles of the Dynamo." He used two small C. & C. motors to illustrate his explanations, and the members left the rooms with a clearer understanding of the dynamo electric machine. There is every reason to suppose that this society will, like its kindred societies in Chicago, New York and Boston, accomplish good work in the future. The next lecture will be held on June 3, and will be on "Rotations in a Magnetic Field."

BUSINESS NOTICES.

Battery Cut-Out.—Attention is called to a simple device for disconnecting gas lighting batteries if accidentally grounded. It is cheap, sensitive, never needs watching, and has no clockwork to be kept wound. Terms furnished by the Electric Supply company of Syracuse, N. Y., No. 105 South Warren street.

Mr. James E. Wilson, formerly superintendent of the Financial Telegraph company, of Boston, is now a partner in the young but active firm of W. P. Adams & Co., Chicago The house has already secured some handsome contracts for McIntosh & Seymour engines, both compound and high pressure.

St. Louis, Mo.—The *Register* of Union City, Mich., where the Heisler Electric Light company, of St. Louis, has just completed the installation of a first-class system, says: "The results obtained have surpassed even the most sanguine expectations of the projectors of the affair, and have given more than general satisfaction."

Jerome Kidder Manufacturing Company: I have used your apparatus, No. 5 (tip battery), with perfect satisfaction, in preference to other manufacturers' instruments. I credit to your instruments the efficiency and qualities you claim for them.- John L. Shoemaker, M. D., 610 North Eighth street, Philadelphia, Pa., May 21, 1889.

Rockford, Ill.—The Rockford Electric company has been and is meeting with large success in the sale of their Mayo dynamo. The capacity of the factory is inadequate to meet the demands for these dynamos. Hence the company has increased its capital stock by $100,000 and will expend this amount of money in enlarging the plant.

Jager & Co., 173 Pearl street, Brooklyn, are still making a specialty of their automatic glass exhaust pumps, used in the manufacture of incandescent lamps. They are also furnishing colleges and other educational institutions with their chemical apparatus, of which they have the highest testimonials. The firm make experimental apparatus for inventors.

Mr. R. M. Huston, 239 Broadway, New York, agent for the Heine water tubes steel safety boilers, has recently sold to the Rochester Electric Railway Company, of Rochester, N. Y., boilers aggregating 800-h. p. for use in their electric power station; also to the Magnetic Iron Ore Company, of Carthage, N. Y., boilers aggregating 300 h. p. They will be built by Van Sile, MacCormack & Co., of Albany, N. Y.

Warning to Investors.—Suit against the United States Aluminum Metal company, of New York, operating the so-called Herault process of electric smelting, has been begun by the Cowles Electric Smelting & Aluminum company, of Cleveland, O. The alleged process of Herault is a gross infringement of the Cowles patents, and investors are hereby warned that we shall maintain these claims to the full extent of the law.

Eugene H. Cowles, President.

The Reliance Gauge Company, of Cleveland, O., report a large increase in the demand for their Reliance safety water columns, and their recent adoption by the Canton, O., Electric Light company; the Mutual Electric Light company, Alliance, O.; and the Brush Electric Light company, Indianapolis, Ind. The manufacturers have some excellent testimonials from the Oneida, N. Y., Electric Light company, and from the Springfield Electric Light & Power company, Springfield, Ill., both of which speak of these instruments in the highest terms.

The Ball Engine Company, of Erie, Pa., report the following recent shipments: The North Western Guarantee Loan company, of Minneapolis, Minn., two 100 h. p. engines for electric lighting for the beautiful block now being built by that company; the Rockport Water company, of Rockport, Ind., a 60 h. p. Ball engine; the Greenwich Gas and Electric Light company, a 100 h. p. tandem compound engine; the Pensacola Electric Light company, of Pensacola, Fla., a 100 h. p. Ball engine; the Manitou Springs Electric Light company, of Manitou, Col., one 80 and one 100 h. p. Ball engines; the Tuscarawas Electric Light company, Canal Dover, O., a 100 h. p. Ball engine.

Messrs. J. H. Siegrist, Jr., & Co., 313 Olive street, St. Louis, Mo., informs us that they have the Brightman Mechanical Stoker under the following boilers at St. Louis. Four at Odd Fellows Hall; four at the new Lionberger building; two at the new D. M. Houser building; two of the Heine pattern at the new Boatmen's Bank building; two at the new Bell telephone building; three at the M. A. Seed Dry Plate company's works; two at the Graham Paper company's works, and numerous others. They have just closed contracts for one to go to the Creston, Iowa, Gas & Electric company; two for the Paducah, Ky., Street Railway company, and five for Louisville, Ky. These machines are designed for economically burning the slack coal, and for preventing smoke. That they are rapidly finding their way into use by electric light plants is evident.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

PATENTS ISSUED MAY 13, 1890.

(1) 427,540. Lightning Arrester. (2) 427,541. System of Electrical Distribution; Louis Bell, of Lafayette, Ind. Applications filed November 7, 1889. (1) The invention consists in locating an impedence coil in the main circuit and locating the arrester points or surfaces between which is the space forming the break in the ground wire in an exhausted chamber; also in combining with the coil and points an automatic switch operated by the passage of electricity through the ground wire to break a circuit of the dynamo, or to interrupt the arc between the arrester points. (2) In a power system of electrical distribution, the combination with a distributing conductor divided into sections, with current-limiting devices between each section, of an independent connection between each section and the source of supply, with a current-limiting device in each of the connections.

427,548. Fuse Block; Charles F. Brush, of Cleveland, O. Application filed November 21, 1889. The combination, with an electric feed circuit, of a fuse included therein, said fuse consisting of two plates of conducting material, a series of metallic blocks located between and in proximity to one of the plates, a fusible strip connecting each block with the other plate, and a plug for electrically connecting the blocks with the plate in proximity thereto one at a time, whereby when one fusible strip shall have been blown another may be quickly put into circuit.

427,549. Electric Prod Pole; John M. Burton, of Wichita, Kan. Application filed March 18, 1890. Consists in providing the prod poles with contact points respectively connected through the medium of insulated wires with the positive and negative poles of an electric apparatus in such manner that when the poles are at rest the electric current will be broken, and when in use in contact with an animal the circuit will, through the medium of an animal, be connected and give an electric shock to the animal.

427,569. Trolley Arm for Electric Cars; William F. Harriman, of Des Moines, Iowa. Application filed Feb. 24, 1890. The combination with an electric car, of an arm horizontally pivoted upon the top and substantially at the centre thereof, the said arm extending toward one end of the car and having secured to it at a point distant from its horizontal pivot a trolley arm inclined toward the centre of the car, whereby the trolley arm may be supported and also be shifted from end to end of the car when desired.

427,571. Alternating Current Apparatus; Edward Heymann and Frank William Heymann, of Boston. Assignors to James E. Maynadier, trustee, of Taunton, Mass. Application filed June 10, 1889. The invention consists in the combination of a core with a main and an auxiliary coil, both coils forming a part of the alternating circuit. The main coil is so wound on the core as to make one end of the core north and the other south at every current, say from left to right—while the auxiliary coil is so wound that the currents, which would be induced in it by alternations of the magnetism of the core are always in the same direction as the corresponding alternations in the main coil.

427,574. Electric Heater; Benjamin Chew Howard, of Baltimore, Md. Application filed Dec. 28, 1889. An electrical apparatus for heating air, consisting of a tube containing a series of resistance coils, and means for causing the air to pass through the coils.

427,589. Guide for Trolley Wheels; Henry A. Marks, of Lynn, Mass. Application filed Feb. 24, 1890. In combination with a trolley and its support, a movable guide extending outwardly beyond the flanges of the trolley, and yielding means for holding the guide in normal position.

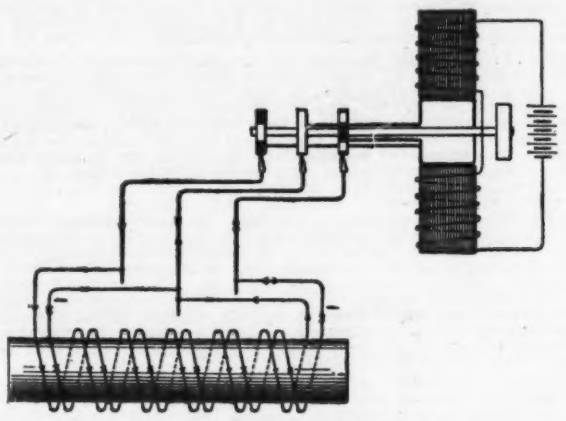
427,606. Electro Magnet; Francis Jarvis Patten, of New York, N. Y. Application filed Dec. 28, 1889. A magnetizing helix consisting of two contiguously coiled strands of wire, one of which conveys only positive currents and the other only negative currents, but in such direction as to produce the same magnetizing effect within the coils.

(1) 427,621. Multiple Switch Board Test System; (2) 427,622. Switch Board; (3) 427,623. Test Circuit for Multiple Switch Boards; (4) 427,624. Multiple Switch Board Test Circuit; (5) 427,917. Charles E. Scribner, of Chicago, Ill., Assignor to the Western Electric Company, of the same place. Application filed, (1) Dec. 6, 1887. (2) July 16, 1886, renewed Feb. 24, 1890. (3) June 1, 1888, renewed Feb. 24, 1890. (4) June 1, 1888, renewed Feb. 24, 1890. (5) July 28, 1884. (1) The combination with the spring jack switch, of a double contact plug

inserted therein, one of the insulated contacts of the plug passing by the switch lever and being entirely insulated therefrom when in place, and the lever of the switch being closed upon the insulated sleeve or shank of the plug. (2) The combination with the spring board, of a spring jack switch having a frame or tubular portion consisting of two parts, the rear portion being tapped out to form a nut and the front portion being in the form of a hollow screw corresponding to the nut. (3) The combination, with a telephone line extending from ground at a subscriber's station through the insulated portions of spring jack switches distributed on different boards and back through the contacts and springs of the spring jack switches and a battery to ground, of a telephone in a ground branch including a vibrator or rheotome and means for closing the ground circuit to the insulated portion of a switch of a line, whereby it may be determined whether the line is open at any other of the series of spring jacks of the line. (4) The invention relates to test circuits for multiple switch boards of a telephone exchange and apparatus for determining at one board whether a line called for is in use at any other of the boards.

427,628. Trolley or Collector Wheel for Electric Railways; Sidney H. Short, of Cleveland, O. Application filed March 18, 1890. A trolley wheel or collector of carbon.

427,674. Carbon Brush for Motors; Leo Daft, of Plainfield, N. J.. Assignor to the Daft Electric Co., of New York, N. Y. Application filed May 23, 1889. A brush or contact maker for



No. 427,606.—ELECTRO-MAGNET.

carrying an electric current to a surface moving thereunder, consisting of non-lubricating carbon and plumbago.

427,710. Composition for Supports for Secondary Battery Electrodes; Walter F. Smith, of Philadelphia, Pa., Assignor to the United Electric Improvement Co., of Gloucester City, N. J. Application filed Sept. 10, 1889. In combination, a battery plate or element composed of active material or material to become active, and a support or frame therefor formed of an amalgam consisting of lead and mercury.

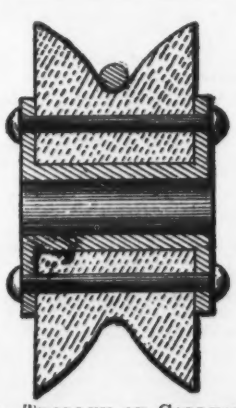
427,711. Fire-Alarm Regulator; Clarence J. Spike and Hedley V. McLeod, of Halifax. N. S., Can., Assignors of one-half to Arthur C. Hawkins, of same place. Application filed Nov. 19, 1889. In an electric fire-alarm regulator, the combination of a dial plate having index arm connected by a pin of cog wheels to an insulating bar, and a cylinder containing a series of pins or with corresponding segments indicating an alarm and means for transmitting the signals automatically.

(1) 427,724. Automatic Electric Cut-Out; (2) 427,725. Electric Railway; (3) 427,726. Contact Device for Electric Railways; Edward M. Bentley, of New York, N. Y. Applications filed (1) March 16, 1888. (2) August 9, 1888. (3) July 5, 1889. (1) In an automatic cut-out the combination, of a contact for making and breaking the main circuit to be protected, an actuating electro-magnet therefor responding to the presence of an abnormal current in the main circuit and a retarded restoring device for the contact, whereby the circuit will be automatically restored to its normal condition after a predetermined interval. (2) The combination, with an electrically propelled vehicle, of two contact devices, one adapted for a single supply conductor and the other for a double supply conductor, both removable into or out of an operative position, and the former provided with a ground connection controlled by one of the two contact devices. (3) The combination, with a moving vehicle and a line conductor, of two contact devices adapted to be brought alternately into engagement with the line conductor according to the direction of travel of the vehicle, and connected together, so that the one is moved into operative position upon the movement of the other away therefrom.

427,742. Telephone Exchange Apparatus; John J. Carty of New York, N. Y., Assignor to the Western Electric Company, of Chicago, Ill. Application filed March 23, 1889. The invention consists in telephone lines, each connected with a different spring jack switch upon one of the switch boards, each line being connected, through an induction coil or converter, with metallic sockets on other boards, one for each line on each of two or more other switchboards.

427,746. Electrical Conductor for the Transmission of Power; William J. Cordley, of Richmond, Va., Assignor of one-half to Walter D. Moses, of same place Application filed Aug. 6, 1889. The combination of a closed conduit or casing of flexible insulating material, a main conductor supported within and held to one side of the interior of said casing, and a contact strip extending through the wall of the casing and secured to the latter opposite the main conductor.

1) 427,748. Electric Meter; (2) 427,749. Method of Measuring and Registering Electric Energy; Stanley Charles Cuthbert Currie, of Philadelphia, Pa., Assignor to the



No. 427,628.—TROLLEY OR COLLECTOR WHEEL.

United Electric Improvement Company, of Gloucester, N. J. Applications filed (1) Nov. 25, 1889, and (2) Nov. 30, 1889. (1) An electric meter consisting of a tank containing a liquid, a buoy supporting an electro magnet, a fulcrumed lever, a float, a soft iron core pivotally connected with the lever, and a siphon secured to the lever and actuated by the magnet included in an electric circuit. (2) The invention relates to a method of ascertaining the quantity of strength of an electric current and accurately measuring and registering electric energy passing through a circuit in a given time.

427,751 Electrical Converter; Sebastian Ziani De Ferranti, of Hampstead, County of Middlesex, Eng. Application filed Oct. 10, 1888. Patented in England Dec. 9, 1885; in France Dec. 9, 1886; in Belgium Jan. 8, 1887; and in Italy March 31, 1887. The combination, with a separately formed secondary coil and its insulation, of a separately wound primary coil covered with insulation, and a core composed of magnetically insulated laminæ of soft iron, which, after the coils are placed in position, are joined to form independent closed magnetic circuits extending around the exteriors of the coils.

427,762. Electric Signal; Josef Haas, Jr., of Vienna, Austria Hungary. Application filed July 10, 1889. In an electric signal the combination with a standard, of an electric lamp on the same, a storage battery or other source of electricity having one pole connected with the electric lamp, an electro-magnet, an armature for the electric magnet, a wire connecting the electric lamp with the armature, a contact piece connected with the storage battery, a local battery, conducting wires connecting the local battery with the electro-magnet, and a circuit-closer for closing the circuit of the local battery.

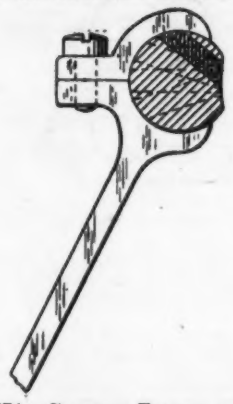
427,783. Electric Circuit Closer for Railway Signals; Frank E. Morgan and Frederic A. Lane, of New Haven, Conn. Application filed June 17, 1889. The invention consists in the construction of a mechanism for making and breaking an electric circuit which will require the exit of every train which may be on the block before the danger signal will be removed, and this irrespective of the number, whether it be one, two, three, or more trains.

427,785. Secondary Battery Electrode; James F. McLaughlin, of Philadelphia, Pa. Application filed March 17, 1890. A secondary battery electrode consisting, essentially, of a mixture of oxide of lead, plaster of paris and sulphuric acid.

427,789. Secondary Battery; Thomas F. Nevins, of Brooklyn, N. Y., Assignor of one-half to John W. Carter and Harry Carey, both of same place. Application filed Dec. 8, 1888. Renewed April 9, 1890. In a secondary battery an electrode having a series of apertures, the edges of which are beveled inward from both faces of the electrode, and a series of apertures between the beveled apertures.

427,823. Electric Plug; William A. Anthony, of Hartford, Assignor to the Mather Electric Company, of Manchester, Conn. Application filed Feb. 23, 1889. The invention consists in a cut-out plug in which the fusible metal is entirely enclosed in plaster or equivalent non-combustible material, the fusible metal being surrounded by the plaster.

427,873. Bilge-Water Alarm; James W. Jones, of New York, N. Y. Application filed May 1, 1889. In a bilge-water alarm, the combination, with a fixed contact point, to which one end of a normally open circuit leads, of a float hinged to its support by an insulation hinge, and carrying connections for completing the electric circuit by contact with the fixed contact point upon the rising of the float.



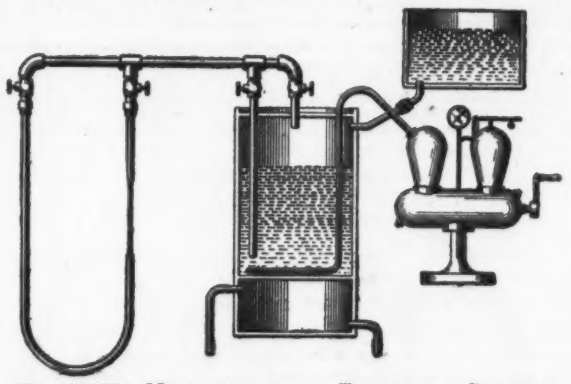
No. 427,674.—CARBON BRUSH FOR MOTORS.

427,876. Telegraph Key; John S. Kaylor, of Bismarck, Ill. Application filed August 26, 1889. In a telegraph key, the combination, with a lower contact, of a sliding spring-pressed bolt, adapted to form a connection between the base plate and the contact point, and a lever pivoted independently of the key lever for operating the bolt.

427,878. Guard and Stay for Electric Railway Wires; Conrad J. Kilian, of Milwaukee, Wis., Assignor of one-half to Dustin Atwood, of same place. Application filed Dec. 30, 1889.

The invention consists of a guard wire stretched over the transmission wire of depending wires connecting the same with the transmission wire at suitable intervals, of guard wires stretched parallel with the transmission wires at one side thereof, so as to prevent broken wires falling across the same from coming in contact with the transmission wires.

427,879. Electric Indicator; Frederic A. Lane, of New Haven, Conn., Assignor to the New Haven Clock Company, of same place. Application filed April 5, 1889. An electric receiver



No. 428,055.—MANUFACTURE OF TELEGRAPH CABLES.

having a locating train, and a signal train a locating indicator connected with one train and a signal indicator connected with the other train, a manual operating lever, and connections between the trains and the lever, whereby both trains are wound up when the lever is operated.

427,953. Electric Train Signaling Apparatus for Railways; Eugene Jacques Jerome de Baillehache, of Paris, France. Application filed Feb. 21, 1889. This invention consists in the use of a fixed elastic insulated metallic plate or bar above the railway sleeper, and placed at a short distance outside and a little above the rail, so that it will be struck by the tire of the wheels of the train. This insulated plate being in communication with a line wire, and the rail communicating with the return line through the earth, the tire of each wheel traveling on the rail closes the circuit and produces the desired signals.

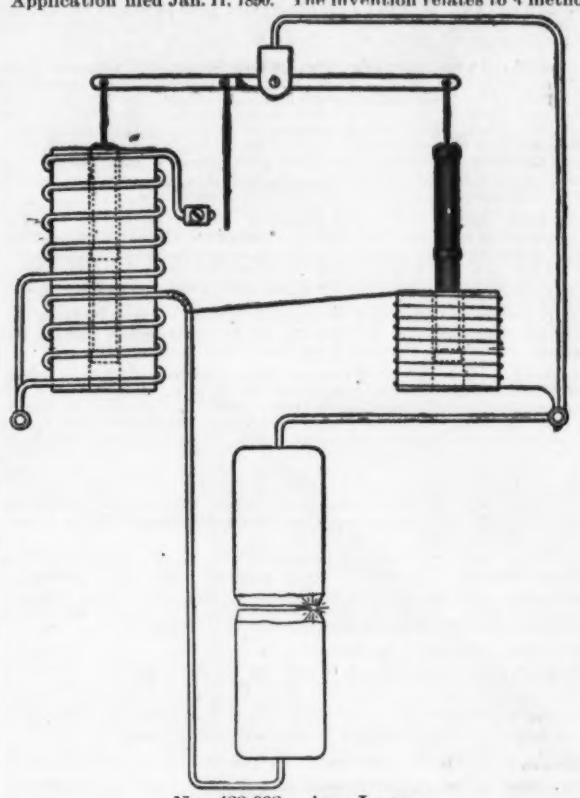
427,971. Method of Electric Welding; Charles L. Coffin, of Detroit, Mich. Application filed April 24, 1889. The process of electric welding, consisting in placing the parts to be welded in close proximity to a voltaic arc, protecting the arc and the parts to be welded by a jacket of non-conducting refractory material, and after sufficiently heating the parts, pressing them together to complete the weld.

427,974. Means for Effecting Communication in Telephone Systems; Louis J. Crossley and Walter Emmott, of Halifax, and John Fred Harrison, of Bradford, County of York, Eng. Application filed July 14, 1886. Patented in England, Sept. 16, 1884. The combination of a telephonic exchange and a user's telephonic instruments with an automatic call box having a slit for the introduction of a coin or other representation of monetary value, a chute for the latter, a circuit connecting the box with the exchange, a lever to be operated by the weight of the coin, and contacts to automatically close the circuit on the deposit of the coin.

427,978. Alternating Current Motor; Michael Von Dolivo-Debrowolsky, of Berlin, Germany, Assignor to the Company Allegemeine Elektricitats-Gesellschaft, of same place. Application filed Nov. 13, 1889. Patented in Germany, March 8, 1889; in France June 24, 18890; in Belgium July 1, 1889; in Luxumburg July 2, 1889; in Italy July 4, 1889; and in Switzerland Oct. 26, 1889. In an alternating current motor, the combination with a field magnet, of an armature composed of an iron body of rotation, bars, strips, or wires of copper arranged transversely to the direction of rotation of the motor, and also transversely to the lines of force of the magneitc field, and copper conductors, whereby the said bars, strips, or wires are connected together at both ends.

427,984. Automatic Lightning Arrester; Claude M. Griffin, of Kansas City, Mo. Application filed Jan. 18, 1890. A lightning arrester having solenoids connected to line, and provided with vertically movable cores connected by a yoke. A rod is suitably connected with this yoke, having at its extremity a toothed casting, and is adapted when the solenoids are energized to be separated from a similar stationary toothed casting after the lightning charge has passed therethrough.

428,008. Arc Lamp; Philip Lange, of Pittsburgh, Pa., Assignor to the Westinghouse Electric Company of same place. Application filed Jan. 11, 1890. The invention relates to a method



No. 428,008.—ARC LAMP.

of producing light by the consumption of electrodes by electric currents, and to certain improvements in the construction of apparatus employed therefor.

428,038. Commutator Brush; Evan H. Bowen, of Akron, O., Assignor of two-thirds to Lewis A. Smith and John Henry Kruse, of same place. Application filed Aug. 8, 1889. The combination, with a commutator of a dynamo electric machine, of a rigid carbon stick and a clamp having a grooved jaw, a compressing plate, and a set screw to receive the stick and retain it against and tangential to the periphery of the commutator.

428,041. Track Instrument for Railroad Signals; Mahlon S. Conly, of Hyde Park, Ill. Application filed Feb. 15, 1889. In the track instrument for railroad signals, the combination, with a rail of circuit making and breaking devices, a piston rod for operating the same, a lever connected with the rail flange at one end, a closed cylinder attached to the opposite end thereof, and a piston on the piston rod working in and actuated by the movements of the cylinder.

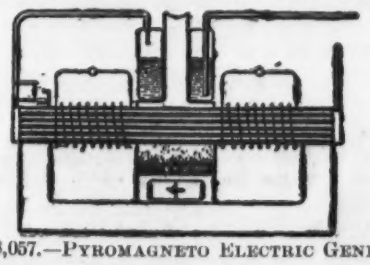
428,042. Method of Producing Alternating Electric Currents; Mahlon S. Conly, of Hyde Park, Assignor of two-thirds to William B. Sterrett, of Chicago, and John J. Weare, of Hyde Park, Ill. Application filed July 9, 1889. The method of producing alternating electric currents in a line circuit, the same consisting in first closing a local battery circuit in which is included a helix, thereby causing the helix to become electro-statically saturated, and then simultaneously opening the local circuit and introducing the line circuit therein, alternately reversing the terminals of the local with the terminals of the line circuit after each closing of the local circuit, whereby the electro-static discharge from the helix will traverse the line circuit in alternately opposite directions.

428,046. Terminal for Electric Cables; Joseph Augustus Hanagin, of Chicago, Ill., Assignor to the Western Electric Company, of same place. Application filed March 25, 1889. The invention consists in placing the metallic cap over each of the ends of the sections of the cable to be united, soldering the conductor to these caps, and then locking the caps together, and, further, protecting sleeve or coupling, which is placed over the joint thus formed in the conductor.

428,050. Ground Detector; Charles H. Macloskie, of Allegheny, Pa., Assignor to the Thomson-Houston Electric Company, of Connecticut. Application filed Aug. 31, 1889. The combination, with a temporarily grounded conductor in an electric distributing system, of a generator having its poles connected with the conductors and the ground, respectively, a circuit interrupter for interrupting the circuit of the generator, and an induction coil with an indicator adapted to be passed along the said conductor to locate the position of the temporary ground.

428,055. Manufacture of Telegraph Cables; William R. Patterson, of Chicago, Ill. Application filed May 14, 1889. The method of manufacturing electric cables, which consists in forcing insulating filling into both ends of a section thereof, and thereby compressing the gas or air between the fillings.

428,057. Pyromagneto Electric Generator; Nikola Tesla, of New York, N. Y., Assignor of one-half to Charles F. Peck, of Englewood, N. J. Application filed May 25, 1889. In an electric generator, the combination with a magnetized core or body, and a conductor within the field of force produced thereby



No. 428,057.—PYROMAGNETO ELECTRIC GENERATOR.

of an inclosed source of heat applied to a portion of the core, and an artificial cooling device for reducing the temperature of the heated portion thereof.

U. S. PATENTS ISSUED MAY 20, 1890.

428,066. Arc Lamp; Charles P. Breese, of New York, N. Y. Application filed Feb. 11, 1890. In an arc lamp, a solenoid magnet wound differentially with series and shunt coils, with its core standing approximately at right angles to the carbon rod in combination with a carbon rod, and a cam pivoted to the core and bearing against the carbon rod.

428,071. Insulator for Electric Railway Wires; Harold P. Brown, of New York, N. Y. Application filed March 10, 1890. The invention consists of an insulating support of glass or other suitable material placed between the two wires attached thereto, so that the crushing strength of the material is utilized instead of its tensile strength or cohesion.

428,072. Trolley System for Electric Railways; Harold P. Brown, of New York, N. Y. Application filed March 10, 1890. The invention consists in providing one of the electric wires at a crossing with a rigid bent support furnished with an opening or

closing latch or arm, so that the trolley will close the latch or arm as it advances, and thus bridge or span the space between the limbs of the bent support, and afford a continuous smooth way or line for the trolley to follow, said bridge having attached thereto an insulator to support the cross wire in position in the hollow or bend of the bent support or bridge.

428,073. Commutator Brush for Dynamos; Lewis Van Brown, of Asheville, N. C., Assignor of one-half to William H. Inloes, of same place. Application filed Aug. 15, 1889. A commutator brush consisting of several strips held rigidly together at one end and loosely at the other, and provided with a keeper placed around the loose ends, such keeper being part of the brush structure and distinct from the ordinary brush holder.

428,075. Apparatus for Detecting Waste of Water; Benjamin S. Church, of New York, N. Y. Application filed September 21, 1889. The combination, with a waste supply pipe and a meter located therein, of a circuit maker and breaker operated by the meter, electric conductors connected to the circuit maker and breaker and terminating at a point accessible from the outside of the building in which the meter is located, and a portable battery and indicator having electric conductors adapted to be connected and disconnected to and from the first conductors.

428,084. Electric Meter; Alphonse Frager, of Paris, France, Application filed Jan. 29, 1890. Patented in France, Jan. 29, 1889. In an electric meter, an electro-dynamometer consisting of a movable coil connected in derivation, and two fixed coils arranged exterior to the movable coil to act inductively thereupon, and the fixed coils wound in opposite directions, connected together at their inner ends and connected at their outer ends to the circuit wire carrying the current to be measured, whereby the entire current to be measured traverses them serially.

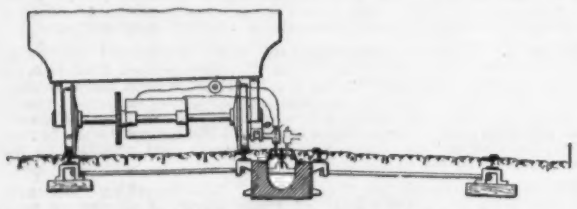
428,087. Process of Electro Deposition; Davis Garrett, of Kansas City, Kans., Assignor of one-half to James Clark, of same place. Application filed Dec. 4, 1888. The process of manufacturing articles having a base metal body and a precious metal surface by electro deposition, consisting in first making a mold or matrix of a metal or alloy fusible at a lower temperature than either of the metals to be deposited; second, depositing a thin film of bright metal on said matrix or mold; third, depositing the precious metal on said thin film of bright metal; fifth, melting away the fusible mold or matrix, and finally removing the preparatory film of bright metal by buffing.

428,095. Electric Signal Circuit; Orlando W. Hart, of Fall River, Mass. Application filed Aug. 23, 1889. The invention utilizes a main circuit provided with a shunt circuit of less resistance than the main and in the latter is placed an alarm adapted to give notice of any trouble on the line.

428,098. Electric Railway; Rudolph M. Hunter, of Philadelphia, Pa., Assignor by mesne assignments to the Thomson-Houston Electric Company, of Boston, Mass. Application filed Jan. 14, 1888. In an electric railway system, a divided or sectional working conductor over which normally no current is passing, separate continuous line conductors and switches to connect the sections of working conductors with either line conductor.

428,116. Galvanic Battery; Archibald J. McDonald, of North Tiverton, R. I. Assignor to Henry E. Townsend, trustee, of Boston, Mass. Application filed August 24, 1889. In a primary battery the arrangement of the positive plates opposite the angle formed between the surfaces of two negative plates, the positive and negative plates being separated from each other by a porous cup.

428,136. Trolley-Arm Support for Electric Railways; Frank B. Rae, of Detroit, Mich., Assignor to the Detroit Electrical Works of same place. Application filed March 13, 1890. In a



No. 428,211.—Electric Railway.

trolley arm support, a base piece, a main supporting piece mounted in the base piece and capable of lateral movement, and a socket piece pivotally mounted in the main support and capable of longitudinal movement.

428,169. Electric Motor Regulator; Walter H. Knight, of New York, N. Y. Application filed June 5, 1889. The invention consists in providing a reversing mechanism for the motor with a stop or lock, so that it can be operated only when there is a sufficient amount of resistance inserted to prevent injury, and, further, in providing a stop or lock for the resistance controller or regulator of the machine, by which, when the reversing mechanism is at the neutral point, the resistance cannot be cut out. These devices prevent reversal of the motor at an improper time, and also the operation of the regulator unless the reversing mechanism is set in one direction or the other.

428,174. Telephone; John C. Ludwig, of San Francisco, Cal., Assignor of one-half to A. C. Paulsell and Martin Corcoran, of same place and T. C. Coogan and H. T. Compton, of Oakland, Cal. Application filed July 6, 1889. In a telephone, the combination of a hollow frame forming a sounding box, the speaking tube or mouth piece connected centrally with the front of said frame, the magnet at the back of the frame, the bobbins of the magnet, the armature of the magnet on the face of the bobbins, and the projecting arm of the armature, the end of which rests against and in contact with the back wall of the frame which forms the diaphragm.

428,175. Electric Locomotive; James F. McLaughlin, of Philadelphia, Pa. Application filed March 17, 1890. In an electric locomotive, the combination, with a continuously rotating armature and two sets of gearing connected with and adapted to impart different speeds to the truck wheels, of two loose gears, two clutches, one for each loose gear and a shifting rod connected to both clutches.

428,189. Three Wire Multiple Switch-Board System; Ernest P. Warner, of Chicago, Ill., Assignor to the Western Electric Company of same place. Application filed Dec. 10, 1888. The invention consists in connecting the different telephone lines with switches on each of the boards of one group and with a switch on one of the boards of the other group, and, in connection with each telephone circuit, running a special signal circuit from each subscriber's station through signal devices, as annunciators, one at least on one of the boards of each of the groups, the signal device of each group or division in each signal line being adapted to respond to current of different polarities or character.

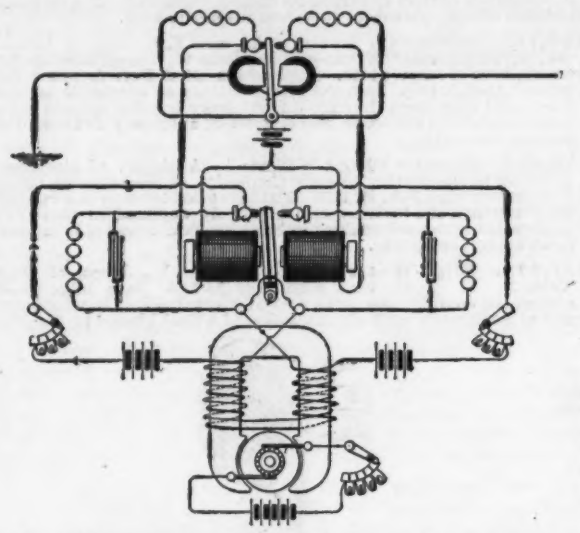
428,210. Electric Railway; Rudolph M. Hunter, of Philadelphia, Pa. Assignor to the Thomson-Houston Electric Company, of Conn. Application filed Feb. 8, 1889. In an electric railway, the working conductors, in combination with a motor or car, connecting devices for conveying electric current to the motor from the conductors, an alarm or electric bell arranged in a branch circuit derived from the motor circuit and receiving electricity from the working conductors, and a switch to open or close the alarm circuit.

428,211. Electric Railway; Rudolph M. Hunter, of Philadelphia, Pa. Assignor, by mesne assignments, to the Thomson-Houston Electric Company, of Boston, Mass. Application filed May 21, 1889. The combination of two tracks with a slotted conduit arranged between them and one or more electrical conductors arranged within the conduit.

(1) 428,221. (2) 428,222. (3) 428,223. (4) 428,224. (5) 428,225. (6) 428,226. Synchronous Multiplex Telegraphy; Francis Jarvis Patten, of New York, N. Y., Assignor to J. M. Seymour, of Brick Church, N. J. Applications filed Jan. 10, 1890. (1) In a system of synchronous multiplex telegraphy, a pair of distributers with transmitting and receiving apparatus, in combination with a pole changer and a signaling battery located in the main line and at a point between two stations. (4) In a system of synchronous multiplex telegraphy the combination of two main lines, one of which includes two or more synchronizing relays and an alternating current generator, said generator being located in the line between two of the relays and the other two or more distributers having independent local earth circuit connections, and signaling batteries with transmitting and receiving apparatus. (5) A main line including an electrical generator, which continuously sets up currents of alternate polarity over the line, and a relay having a reed or ribbon armature kept continuously vibrating in combination with an auxiliary relay included in a local battery with the reed or ribbon armature and a local sounder included in a second local circuit with the armature of the auxiliary relay. (6) In a distributer for synchronous multiplex telegraphs or analogous apparatus, a series of distributing segments arranged in cylindrical form around a rotary axis carrying a brush which bears against the inner cylindrical faces of the segments.

428,247. Magnetic Lock; William W. Fenner, of Kansas City, Mo. Assignor of one-third to Emma Rhodes, of same place. Application filed January 31, 1890. The combination with a lock provided with a bolt, a shaft and pinion normally locked against rotation for operating the said bolt, a barrier for preventing the unlocking of the shaft and pinion, and a magnetizable pin or pins connected to the shaft and normally blocked by the barrier, in combination with a magnetic key for placing the barrier and pin in a non-obstructive relationship to each other.

428,256. Magnetic Lock; John Schneider, of New York, N. Y. Application filed March 5, 1890. In an electric door opener, the combination of a rotary nose, a lever pressing at an angle



No. 428,221.—Synchronous Multiplex Telegraphy.

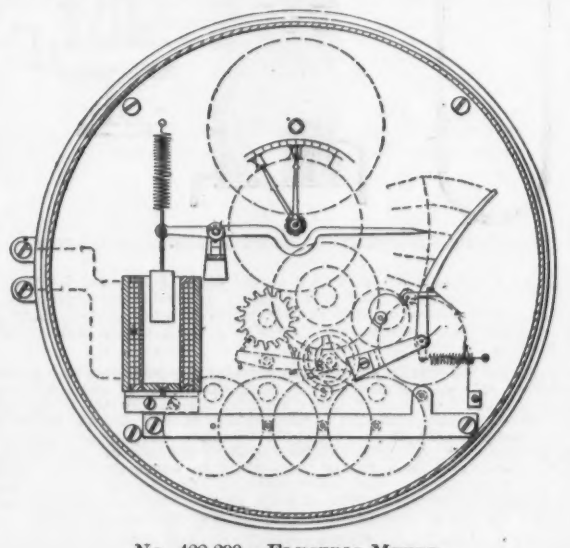
upon the nose, and means for releasing the lever, consisting of two armatures pivoted at right angles to one another, and engaging with each other, one armature normally pressing upon the said first named lever.

428,280. Electric Meter; Jacob F. Mehren, of Chicago, Ill., Assignor to the American Electric Meter Co., of same place. Application filed October 7, 1889. In an electric meter, the combination, with a suitable registering apparatus, of a prime motor in the main circuit, intermediate mechanism connected with the said registering apparatus and controlled from the prime motor to regulate the speed of registration according to the variation in the current on the main circuit, a normally open derived circuit, a pendulum connected with the said intermediate mechanism an electric motor for the pendulum in the derived circuit, and a commutator in said derived circuit actuated by the vibrations of the pendulum alternately to shunt portions of the said electric motor.

428,289. Armature for Dynamos, etc.; Albert Schmid, of Allegheny, Assignor to the Westinghouse Electric Company, of Pittsburgh, Pa. Application filed June 6, 1889. The invention consists in constructing an armature core with teeth projecting radially from the body of the armature and having lateral lugs, beneath which the coils are placed and held in position. These coils and bobbins are previously wound and insulated, and in applying them to the core they are slipped over the teeth and pressed beneath the lugs and secured in position.

428,290. Electric Meter; Ernst Werner Von Siemens, of Berlin, Germany. Application filed Dec. 9, 1890. Patented in Germany Feb. 7, 1889; in England, July 15, 1889; in Switzerland, July 20, 1889; in Belgium, July 24, 1889; in France, July 24, 1889, and in Italy, Sept. 19, 1889. The invention consists in the continuous measurement, at successive regular intervals of time, of the product of the strength and potential of a current passing through a conductor, and to totalize the same by means of a counter or registering mechanism, under the assumption that the indications obtained from the counter will correspond without material error to the actual consumption of electrical energy.

428,317. Regulator for Electric Current Generators; Gustav Pfannkuche, of Cleveland, O. Application filed June 8, 1889. In a dynamo electric machine, the combination, with the shaft, a band pulley loosely mounted on the shaft, a spiral feather or key connecting the band pulley to the shaft, and a spring for forcing the band pulley in one direction, of a longitudinally ad-



No. 428,290.—Electric Meter.

justable rod connected at one end with the band pulley and arranged to transmit motion to suitable devices for adjusting the relative position of the commutator and brushes.

428,358. Cut-Out; Nathan P. Stevens, of Concord, N. H. Application filed Nov. 15, 1889. In a switch or cut-out, the overlapping bars, to which are connected the conducting wires, one of the overlapping bars having a perforation near one end, and a yoke mounted thereon, having a perforation opposite to that in the overlapping bar, spring actuated bar loosely mounted therein, and a single pull cord attached to the latter, whereby the spring actuated bar may be lodged at either side of the perforation in the overlapping bar, or passed through the perforation and rest upon the other overlapping bar.

428,380. Dynamo Electric Machine or Electric Motor; Edgar Croasdale, of Philadelphia, Pa. Application filed January 26, 1886. In a dynamo electric machine or electric motor, the combination of two curved pole pices of magnetic material having each one or more outwardly projecting cores, each of which is made of magnetic material and of two concentric parts, the exciting wire being wound first upon the exterior of one of the parts and then between the two in such direction as to concentrate the magnetic lines of force at the interior poles of the core.

428,420. Voltaic Armor; Albert L. Scott, of Allegheny, Pa. Application filed Feb. 20, 1890. In voltaic armor, a combination of the series of element plates, each having T-shaped heads and slots into which the T-shaped heads of the adjoining plates enter, so as to connect the element plates together.

428,427. Registering Attachment for Telephones; Robert J. Story, John T. Story, Albert E. Fox and George J. Hill, of Buffalo, N. Y. Assignors of one-fifth to George F. Fox, Jr., of same place. Application filed Aug. 14, 1889. The combination, with the signal shaft, of a telephone box, of a registering apparatus, a cam to vibrate a pawl arm, a sleeve rigidly secured to such cam, having a notch at one end, a shaft within said sleeve having a detent to catch in said notch and connected with the telephone signal shaft and mechanism for making the sleeve carrying shaft longitudinally adjustable, so as to turn with or without the sleeve and cam.

428,433. Electric Gas Lighter; Robert T. Walton, of Philadelphia, Pa. Application filed July 18, 1889. An electric gas lighter, consisting of a burner having a key with ports, an electrode at the tip of the burners, a series of arms connected with the key, provided with wipers and means for rotating the key, whereby the gas may be turned on or off by operation of the key in the same direction and the wipers successively contacted with the electrode.

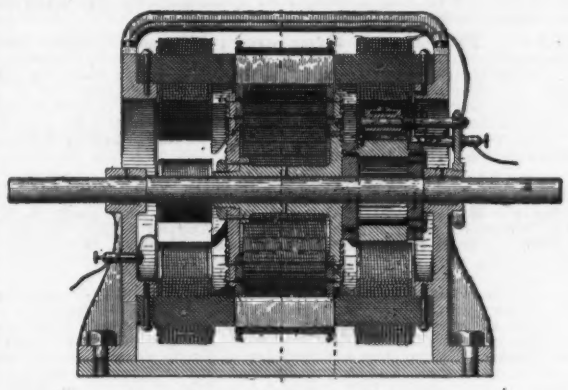
428,435. Alternating Current Arc Lamp; George Westinghouse, Jr., of Pittsburgh, Pa. Application filed May 19, 1890. In an alternating current arc lamp, confronting electrodes having extended edges, the upper electrode being of greater thickness than the lower.

428,443. Electrical Heater; John I. Ashbaugh, of Chattanooga, Tenn. Application filed Oct. 21, 1889. An electric heater, consisting in the combination of the solid baked brick of fire clay or clay mixture, a conducting wire embedded therein, and a metallic jacket or casing surrounding the same.

428,454. Electric Motor; William H. Chapman, of Portland, Me., Assignor to the Giant Electric Motor Company, of Boston, Mass. Application filed Dec. 30, 1889. In a multipolar motor, the combination of a plurality of groups of equal number of armature magnets arranged in a circle about a common center, the magnets in each group being located equidistant from each other about the circle and connected permanently together as one magnet, and the several groups being connected to each other in succession, a commutator having as many segments as there are armature magnets and arranged in corresponding groups, the segments in each group being connected together as one, and each group of segments being connected with corresponding points of junction of the several groups of armature magnets, and a field magnet composed of a series of electric helices having a plurality of both north and south pole ends, the cores and pole ends of said helices being each made up of a series of plates which extend the whole length of the core to the pole end and having its pole end expanded laterally and curved tangentially to a plane at right angles to the axis of the revoluble portion of the motor.

428,459. Process of Welding Metals Electrically; Charles L. Coffin, of Detroit, Mich. Application filed March 7, 1890. The process of welding metals electrically consisting in making contact between the two parts to be welded and an electrical conductor passing heating currents through the articles to be welded and said conductor, removing the articles to be welded from contact with the conductor when brought to a welding heat, and pressing them together to form the weld.

428,481. Electric Motor or Generator; Henry Groswith, of Philadelphia, Pa. Assignor by direct and mesne assignments, of part to Charles W. Kennedy and Ransom F. Rankin, of same place. Application filed Aug. 13, 1889. A magnet for elec-



No. 428,454.—Electric Moter.

tric motors, consisting of a yoke and electrically and magnetically connected field magnet cores, each composed of primary and secondary cores reversibly wound with conducting wires.

428,482. Low Water Boiler Alarm; Orrange G. Guss, of Lima, O. Application filed Sept. 9, 1889. The invention consists of a metallic tube of an expansive nature, securely supported from the pipe connections of the boiler, whereby when the tube expands or becomes lengthened by means of steam issuing therein causes an electric circuit to be completed by means of two metallic plates which are connected to the two wires respectively leading from an electric alarm.

428,499. Electric Railway; Jerome B. Legg and John Nile, of St. Louis, Mo. Application filed Oct. 10, 1888. In an electric railway, a conduit formed of unobstructed sectional circular tubing having a slotted upper side, the exterior horizontal flanges on the bottom by which it is supported, the transverse ears, by which the sections are united, and the conductors depending from the slotted top, whereby an unobstructed conduit is formed.

428,540. Electric Bath Brush; Robert E. Williams, of Dallas, Tex., Assignor of one-half to Wilbur F. Shook, of same place. Application filed Feb. 26, 1890. In an electrical brush, the combination of a top or upper portion having its under side hollowed or recessed, a galvanic battery consisting of side sections fitted in said recessed portion, a cover for the battery, having a central ridge separating the side sections, a copper rod connecting the positive and negative ends of the battery, a flexible brush fitting in the recess of the upper portion and bearing against the battery, electrodes arranged at opposite ends of the brush, and means for connecting said electrodes with the ends of the belt, designated as the positive and negative ends.

428,545. Electric Insulator; Emery Andrews, of Kennebunk, Me., Assignor to the Leatheroid Manufacturing Company, of same place. Application filed Jan. 24, 1890. A molded and vulcanized insulator composed of a solid inner core of some strong insulating material, as leatheroid, and an inclosing covering or envelope composed of a mixture of ground or comminuted leatheroid and rubber thoroughly intermingled.

428,562. Electric Communication with Railway Trains; Thomas J. Houck, of Baltimore, Md., assignor of one half to John T. Wood, of same place. Application filed Nov. 6, 1889. The object of the invention is to provide a railroad with means for telephonic or telegraphic communication between terminal stations and any one or all the moving locomotives distributed along the road between the said terminal stations.

428,564. Electrical Cut-Out; William J. Jenks, of New York, N. Y. Application filed Dec. 10, 1888. The combination consists of two conducting surfaces separated by an air space, each electrically connected with one side of the lamp circuit, and held rigidly at such a slight distance apart that such air space will be bridged by a metallic connection upon the occurrence of a disruptive discharge upon the rupture of the lamp filament.

(1) 428,574. Electrical Converter; filed Nov. 23, 1886. Patented in England July 12, 1887; in France, July 12, 1887; in Belgium, July 12, 1887; in Germany, July 12, 1887; in Italy, July 12, 1887, and in Canada, Nov. 10, 1887. **(2) 428,575. Method of Building Electrical Converters;** William Stanley, Jr., of Great Barrington, Mass., Assignor to George Westinghouse, Jr., of Pittsburgh, Pa. Application filed March 6, 1889. Patented England, France, Belgium, Germany, Italy July 12, 1887, and in Canada Nov. 10, 1887. (1) A core for electric converters, composed of separate E-shaped plates symmetrically disposed about the coiled conductors. (2) The method building electrical converters having laminated cores which consists in first winding and forming the coils of the converters, and subsequently building up the cores around such coils by inserting within and extending around such coils the laminæ of the cores, such laminæ being alternately applied from opposite sides.

Copies of the specifications and drawings complete of any of the patents mentioned in this record—or of any other patents issued since 1866—can be had for 25 cents. Give date and number, and address The W. J. Johnston Co. Ltd., Times Building, N. Y.